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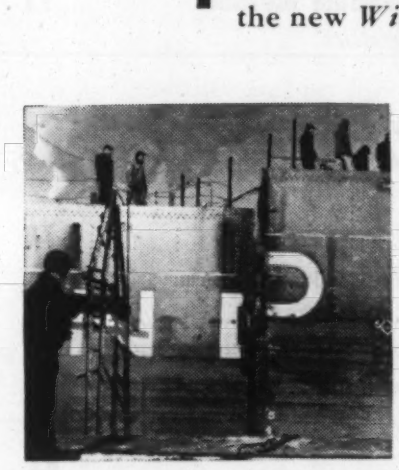
STRETCHING

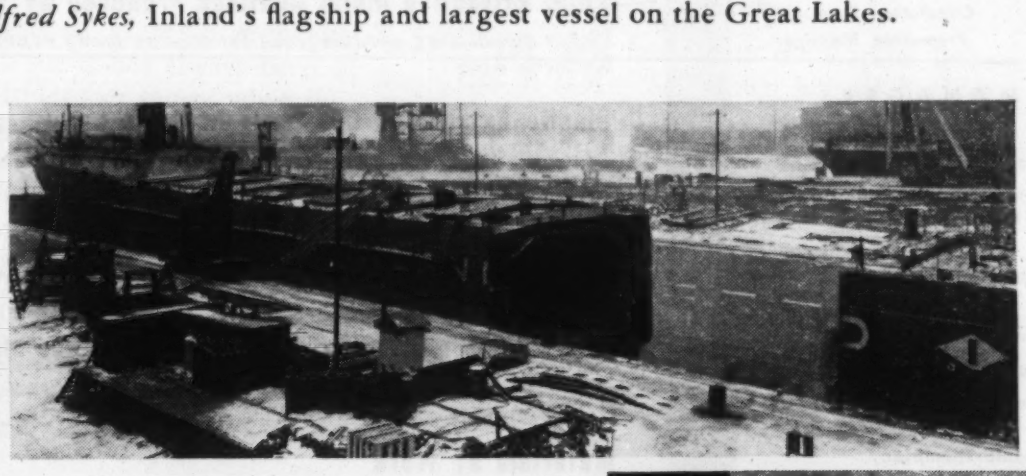
a ship stretches steel supply . . .

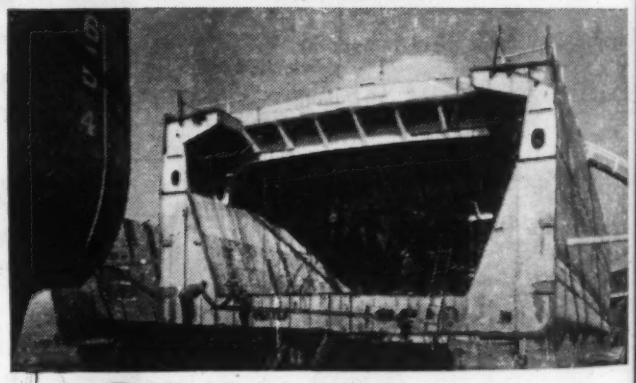
Inland boosts ore carrying capacity by adding 72 feet to the *Philip D. Block*

40,000 more tons of much-needed ore is made available to Inland Blast Furnaces each year.

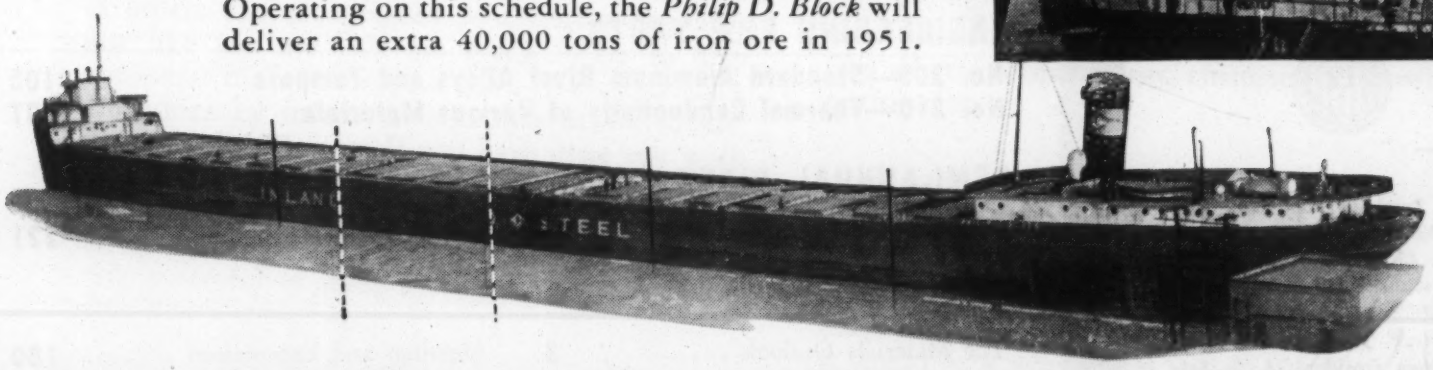
1 A "before" photo of the *Philip D. Block* showing where ship is to be cut in half. This ship, built in 1925 had an overall hull length of 600 ft. Lengthening will bring the *Block* to within 6 ft. of the new *Wilfred Sykes,* Inland's flagship and largest vessel on the Great Lakes.





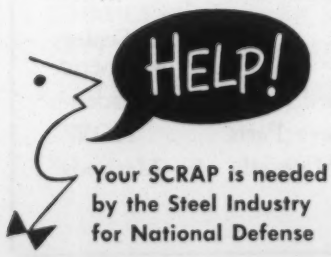


2 Ship has been opened amidships, floated apart and is ready to receive new 72 ft. midsection. Addition of this section will give the ship an average carrying capacity in excess of 14,000 gross tons. Previous average tonnage was 12,800. In a normal lake shipping season, this vessel will make 33 complete round trips between the ore docks at Superior, Wisconsin, and Inland's mill at Indiana Harbor. Operating on this schedule, the *Philip D. Block* will deliver an extra 40,000 tons of iron ore in 1951.



3 New mid-section is in place and reconstruction complete. Total time in drydock: 100 days. The *Philip D. Block* has since joined her four sister ships, and the many other lake ore carriers, in the important task of supplying iron ore to a nation counting more than ever on a big year in steel.

The lengthening of the *Philip D. Block* is just one more step in a continuing modernization and expansion program at Inland.



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INLAND

The Materials Outlook

As a flood of paper rushes into Washington preparatory to the start of the CMP, there are already suggestions that materials other than steel, aluminum and copper will be added to the list. Actually, shortages of some materials, such as nickel and zinc, will have more effect on materials allocations than the CMP itself. It would be useless to pass out all of the controlled materials that are asked for if they cannot be used due to the lack of some materials that are even less available.

For example, many products will be stymied completely if they rely too strongly upon nickel. The proposed jet engine program as of now demands more nickel than will be available for all industry. Possibly some of this demand can be scaled down, but even so, this one use will eat up the major share of nickel. With knowledge of shortages of this nature, CMP and NPA officials will only allow enough other materials to mesh with the nickel supply.

For the third quarter the overall materials supply will be pretty tough, according to industry spokesmen in Washington. Pessimism is due to the fact that DO orders will be all mixed up with the initial quarter's operation of the CMP. Undoubtedly this will cause serious confusion and dislocation.

Officially, but off the record, CMP heads will be both happy and surprised if CMP is smoothly functioning by the last quarter of this year.

Many of our materials problems today are due essentially to political conditions in this country and abroad. Our allies as well as our active and anticipated foes are bidding up the prices of materials which we urgently need. Prices on world markets are several cents per pound higher than our users are allowed to pay for such materials as copper and lead.

A new possibility for some high temperature applications is molybdenum, which has been given a molybdenum silicide coating. Although molybdenum retains most of its properties at high temperatures, it oxidizes when it reaches a dull, red heat. The new coating protects molybdenum parts against oxidization up to 3000 F, and resists attack by other gases, including combustion gases. The coating is electrically conductive and will not flake, peel or spall.

Some idea of how the use of plastics has grown is gained from the latest figures released by the Society of the Plastics Industry. During 1950, more than 1,650,000,000 lb of synthetic resins were produced in the U. S.

(Continued on page 4)

The Materials Outlook *(continued)*

-- more than double the production of 1945. In 1922, the year the industry got its start, only 5,944,133 lb were produced. Even with this production, several types of plastics materials are now under allocation.

Contributing to the great increase in resin production is the rise in importance of the thermoplastics, which now are being used at a rate 17 times higher than in 1940. The 1950 output was 685,000,000 lb. Raw materials shortages, plus high plant investment costs, will probably slow down this expansion rate considerably. However, most thermoplastics, particularly the cellulosics, should be in ample supply by the last quarter of this year.

As we now reach a period when armament production goes into high gear, we must face the fact that something has to give. The guns and butter theory has worked reasonably well up till now, but it would appear that the civilian portion of our economy will soon have to take a back seat. Even as early as April of this year, defense needs were taking approximately one-half of our steel output. Much of this use was in auxiliary products, such as freight cars and pipelines. Now that tanks and artillery are to be included, the proportion will be even higher. Thus, the once optimistic feeling that most materials -- and steel in particular -- would be relatively plentiful by late fall has all but disappeared. Along with that change in attitude have come the predictions that many civilian goods will be on the scarce list even though warehouses are now crammed.

Recent tests indicate that waxes will assume an important role in metal working, particularly in drawing stainless steel and aluminum. Under production conditions Type 405 stainless steel has been drawn 50% beyond the theoretical capacity of the metal by using the wax. Tool wear in producing 2000 pieces was so slight as to make measurement impossible with standard instruments. Wax has also taken the place of copper flashing on stainless steel wire for cold heading.

Even though many schemes have been tried with the view of producing iron direct from the ore without blast furnaces, none as yet shows commercial possibilities, according to a report made to the American Iron and Steel Institute. Under all plans tried, conventional steelmaking practices had to be resorted to in order to convert the iron into usable form. Some magic process has been the goal of inventors and scientists for many years in the hope that the heavy investment in steelmaking equipment could be substantially reduced. Another goal, of course, has been to make practical the establishment of smaller mills that could be operated more economically.

There is a growing feeling in some segments of industry that the stockpiling program of the government could be slowed down or even stopped in some cases to ease the supply situation in some materials. Indications are that both the government and some big users of aluminum are, in effect, hoarding by building up inventories long before they can use the metal. If and when the CMP starts working effectively, this situation might clarify itself because of the very definite limitations on inventories.

News Digest

Corning Opens Glass Center

Plans have been announced for the world's most comprehensive facilities for research and education in glass. They will be provided in a new building, the Glass Center, in Corning, N. Y., dedicated to the history, art, science and industry of glassmaking.

It will embrace the most complete reference library of glass in existence and a museum housing collection of glass objects representing every field of glass-making in history. Included, too, will be a new Steuben Glass factory with spectators' galleries from which may be observed at close view all the production operations in making hand-blown fine glass, from furnace to finishing room.

The three-fold expansion of research facilities, involving the fullest possible assemblies of material in the Corning Museum of Glass, in its reference library, and in an actual producing plant, is expected to provide immediate service to the entire glass industry as well as serving mankind generally. It was stated that if needed, the new Steuben factory will be readily convertible to defense purposes. As soon as the new plant is in operation, the present Steuben furnaces will be turned over to other production.

In constructing the Corning Glass Center, glass will be used for the exterior walls, where it will be combined with steel, and also for parts of the roof, interior walls, floors and divisions. The building will demonstrate the varied uses of glass, from glass blocks to glass fibre draperies. Use of glass in these many ways will emphasize all its qualities, from the hardness and protective characteristics which make it suitable for sanitation and longevity, to its absorbency in fibre form when employed for insulation and acoustical treatment.

Materials Papers to Be Presented at ASTM Meeting

Seven technical symposiums and many other technical papers on a wide range of subjects in the field of engineering materials are on the program of the 54th Annual Meeting of the American Society for Testing Materials at Chalfonte-Haddon Hall, Atlantic City, June 18 to 22, inclusive.

An important feature of the program also will be the Edgar Marburg Lecture, to be given by Frank L. LaQue, international authority on corrosion, and in charge of the Corrosion Engineering Section, International Nickel Co., Inc., who will discuss corrosion testing.

Beginning Sunday, June 17, and extending through Friday, June 22, there will be an estimated 450 meetings of the various ASTM technical committees. Several of these committees have cooperated in developing the technical symposiums featuring the ASTM program.

The symposium topics are: (1) flame photometry; (2) structural sandwich construction; (3) acoustical materials; (4) consolidation testing of soils; (5) surface and subsurface reconnaissance; (6) bulk sampling; and finally (7) ultimate consumer goods.

In addition to the symposiums, there will be several dozen other technical papers dealing with ferrous and nonferrous metals, including high temperature properties and testing; a separate session dealing with lead and its uses; with other papers on asphalts, cement and concrete, and plastics.

From the standpoint of the materials engineer the most interesting sessions would perhaps be the ones covering structural sandwich construction, fatigue, the effect of temperature on metals, and creep in nonferrous metals.

The papers on sandwich construction cover the history and general design trends in the field, and deal specifically with paper and aluminum sandwich constructions, fabrication techniques for structural sandwich constructions, and recent developments in inorganic core sandwich constructions.

The two sessions on fatigue include presentations on the damping, elasticity and fatigue properties of temperature resistant metals, the dynamic stress-strain properties of mild steel, fatigue tests in axial compression, the effect of residual stress on the fatigue strength of notched specimens, and the influence of cold work and heat treatment on the engineering properties of beryllium copper wire. Another set of papers covers the planning and interpretation of fatigue tests, the fatigue strengths of ball bearing races, the statistical nature of fatigue, and the influence of surface roughness on the fatigue life and the scatter of test results of two steels.

The papers on nonferrous metals are devoted mainly to testing techniques, creep, aluminum alloys, lead and copper. Several important application problems are discussed for each metal. The fatigue life of lead cable sheath and acid lead and compression tests on lead alloys at extrusion temperatures are covered; the creep properties of 63S and 2S-O aluminum alloys and some forged and cast alloys are presented; and the creep characteristics and mechanical properties of copper at various temperatures are discussed.

News Digest

Materials Advances Announced at du Pont Laboratory Dedication

Wilmington, Del. — Studies that have been carried on by research men in the E. I. du Pont de Nemours & Co.'s Grasselli Chemicals Laboratory on a sand-derived material called GS-199S silica to thicken oil in making grease were disclosed here in one of a series of exhibits presented to some 200 of the nation's leading academic and industrial scientists for the dedication of du Pont's $30,000,000 addition to its Experimental Station.

Like carbon, which occurs both as coal and diamond, silica may take many different forms, the most common of which is ordinary sand. The new form of silica, developed in du Pont laboratories, comes in the form of balls less than a millionth of an inch in diameter. Unlike somewhat similar materials made both in this country and in Europe, the new du Pont silica floats on water, due to special treatment of the minute particles. Without this treatment, the silica would not be satisfactory as a thickener for grease because, under certain conditions, it would separate out and the grease would lose its consistency.

Ordinary greases are made with soap as the thickening agent. At high temperatures, however, such soaps become thin, and this may result in increased wear on bearing surfaces, and the leaking of lubricant from gear and bearing housings.

Greases thickened with GS-199S silica retain their consistency as the temperature rises. This was demonstrated to Grasselli laboratory visitors by the difference in behavior of ordinary grease and silica grease when a lump of each was heated on an electric grill. The conventional grease slumped down. The silica-containing grease stood up.

Researchers emphasized that silica greases are still in the experimental stage, and while promising, have yet to be thoroughly tested, both in the laboratory and under actual service conditions. Experiments conducted thus far, however, show that silica grease resists water and mechanical breakdown as well as heat.

The new Grasselli Chemicals Dept. laboratory resembles the other new Station buildings. Altogether, 19 new buildings, including nine new laboratory buildings, were erected in the Experimental Station expansion.

Plexiglas Engine Built by Design Engineers

Unusual craftsmanship in plastics is represented in the visual study model of a four-cylinder gasoline engine, recently made of acrylic plastic by Philip A. Derham and Associates, design engineers of Rosemont, Pa.

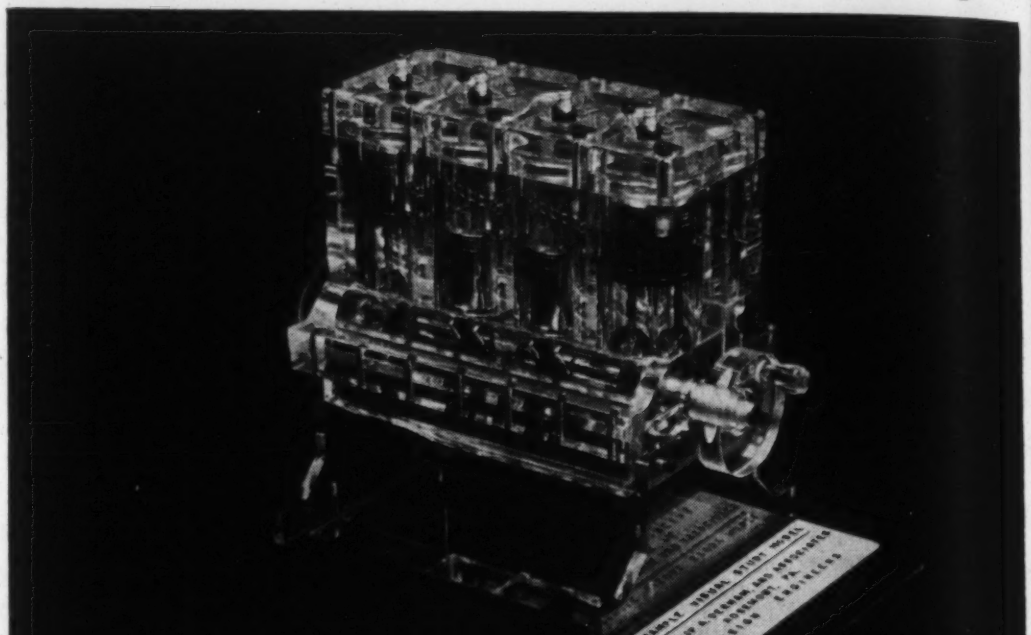
The assembly, designed and fabricated to illustrate the close tolerances which could be held and the perfect visibility of working parts attainable in industrial models with this transparent material, measures about 8 in. long, 6 in. deep and 4½ in. wide. Block, cylinder head, crankcase, flywheel and motor mounts were machined from solid clear Plexiglas. The timing gear cover was heat-formed from ⅛-in. thick sheet of the same acrylic plastic.

Extreme accuracy and care characterized the fabrication and assembly of the model. Cylinder bores, for example, were machined to a tolerance at room temperature of —0.0, +0.001. Final dimensions were attained by careful control of buffing and polishing. Such close tolerances were held because the builders foresaw extensive use of the little engine over a period of years.

Bore is 1.218 in., stroke is 1.125 in., giving a piston displacement of 5.24 cu. in. and an A.M.A. rating of 2.2 hp. Compression ratio at 3.7 to 1 was deliberately held low to facilitate spinning the motor by hand or by a belt drive to an external flywheel from a small electric motor.

Pistons, wrist pins, connecting rods and valves were machined from aluminum. Rings, too, were aluminum, and were designed to give a minimum of scraping action. Valve springs were hand wound from steel wire. Brass was used for the crank shaft, cam shaft and their main bearings. Polyethylene cams were used; rod bearings are aluminum, and the timing gears brass and steel. Spark plugs were those made for model airplane engines.

Cylinder bores were drilled, then cleaned out with a boring bar operated at slow speed, with kerosene used as both a coolant and cutting oil. The slight tool marks remaining were removed with a flexible shaft buffer and medium cut buffing compound. Final polishing of cylinder walls and other machined surfaces was done with white chalk.



Plexiglas model of a 4-cycle engine was made by design engineers for study purposes. The pulley permits manual operation or slow-speed drive from a small electric motor.

Powder Metallurgy in Defense Theme of Metal Powder Show

The busy, rapidly growing powder metallurgy industry held its seventh annual meeting in Cleveland, Apr. 25-26, and over 500 technical men registered for the meeting, which included both technical sessions and exhibits on the latest advances and developments in the field. The role of powder metallurgy in the present defense program was the theme of the meeting, and a number of papers bearing directly on this timely subject were presented.

Sintered Iron Rotating Bands

In connection with the present defense program, the iron powder producers and the metal powder fabricators are vitally interested in the possibility of adopting sintered iron rotating bands as a substitute for conventional gilding metal bands. A. M. Burghardt, Watertown Arsenal, in his paper "Sintered Iron Rotating Bands for Ordnance Use," reviewed the developments to date on this project.

Standardization of sintered iron bands for certain specific high velocity projectiles is proceeding rapidly. In this high velocity development a conservative view has been taken in the choice of mechanical properties that have been incorporated in the band blank. A high quality hydrogen reduced mill scale has been employed that provides a good combination of strength and ductility for the density levels to which the material is fabricated. Sintered iron blanks with densities of 5.5 to 6.0 g/cc are presently being used. It is known that sintered iron of this density range can be expected to have tensile strengths of 10,000 to 20,000 psi, and elongation values of 2 to 8%. If, however, the elongation of the band blank falls below 3%, difficulties may be encountered in seating operations. In contrast, gilding metal blanks have a tensile strength of 35,000 psi and elongation values of 35 to 40%. The lower strength and ductility of sintered iron must be duly considered to insure that the band can be satisfactorily seated on the projectile, will engrave properly in the gun barrel, and will not discard during flight of the projectile.

In the near future, a sizable order of sintered iron bands, for certain specific types of high velocity projectiles, will probably be placed. This program is small, however, in comparison to the overall ammunition program. Preliminary firing tests are also being conducted with sintered iron bands fitted on standard ammunition of medium caliber. If these latter tests prove satisfactory, the program may be broadened to include tests on the smaller caliber projectiles. Small bands are, of course, ideal for the powder metallurgy process. Gun barrel wear caused by sintered iron bands requires further study, and gun wear tests are planned for the near future.

Present investigations are employing bands made of commercially available, straight iron powders. Strength requirements may exclude the use of certain powders in specific cases. For standard ammunition, which is manufactured in greatest quantities, it is anticipated that many different types of powder will be applicable for bands from the strength viewpoint.

Metal Powder Projectiles

Another possible ordnance use for metal powders is in small arms ammunition. G. A. Miller, Jr., Frankford Arsenal, outlined the possibilities in this field in his paper "Metal Powders in Some Small Arms Ammunition Applications".

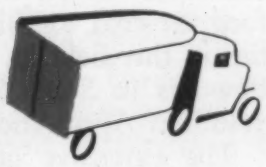
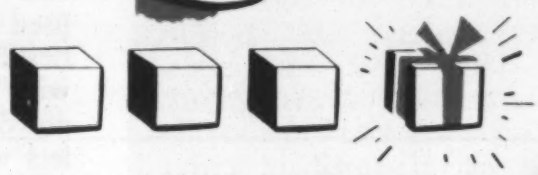
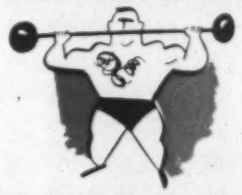
The extensive utilization of lead for so many purposes has created a need for a substitute for this important material in bullets which are used in short range or training activities. Experiments are being conducted with a caliber .30 bullet made of powdered iron. The preliminary bullets were turned from rod produced from powdered iron. It is preferable that the bullets be molded and finished by methods not requiring turning for finishing because in the quantities which might be required, turning on lathes or automatic screw machines would be completely im-

(Continued on page 13)

News Digest

Matter of Fact
BY EDWARD A. JOSEPH
ONE OF THE MOST EXPENSIVE BABY RATTLES EVER PURCHASED WAS THE
ALUMINUM
RATTLE BOUGHT FOR THE SON OF
NAPOLEON III
ITS PRICE IN 1856, WHEN ALUMINUM WAS CONSIDERED A PRECIOUS METAL, WAS
$3200
AN AVERAGE OF OVER 44,000,000 GROSS TONS OF
..SCRAP..
IS CONSUMED EACH YEAR IN AMERICA'S STEEL PLANTS, PERMITTING THE CONSERVATION OF SOME
90,000,000 NET TONS OF
IRON ORE,
SINCE SCRAP REPLACES PIG IRON IN STEEL MAKING PROCESSES
OVER HALF OF THE WORLD'S OUTPUT OF STEEL IS PRODUCED IN THE U.S.
G.I.'S HELMETS, DEVELOPED DURING WORLD WAR II CAN WITHSTAND A .45 CALIBER BULLET FIRED AT
POINT BLANK
RANGE WITH A MUZZLE VELOCITY OF 725 FEET PER SECOND

How to make more with less steel...

Whether you make dragline buckets feed troughs truck trailers  with Inland HI:STEEL, you can retain the same structural strength yet save enough steel on every three units to fabricate a fourth one!  Where payload is important extreme strength and elimination of deadweight essential HI:STEEL is the answer. When you must make your product stronger  or make it lighter or make it last longer without increasing your steel tonnage HI:STEEL is the answer. HI:STEEL's yield point is nearly twice as high as ordinary structural-grade carbon steel, plus superior notch toughness and fatigue strength. HI:STEEL's resistance to atmospheric corrosion is four or five times as much as ordinary carbon steel. Abrasion resistance may be improved as much as 12 times over ordinary carbon steel, depending on the abrasive medium. No change in shop practice is ordinarily required when fabricating HI:STEEL.

INLAND HI:STEEL

INLAND STEEL COMPANY: 38 So. Dearborn St. Chicago 3, Ill.

SALES OFFICES: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul

practicable. [A molded and sintered .30 caliber experimental bullet was on exhibit at the Show.—*The Editors.*]

So far as tests have been completed, the pressure velocity relationship of the cartridges appear normal and the accuracy is reasonably good, but not as good as can be attained with the conventional bullet. Also, the hardness of the bullets, which averaged Rockwell B73, is quite high and indicates possible trouble from barrel erosion, which should not be expected if the bullets are molded to shape; but again, the requirement for high density may mitigate against favorable hardness values being possible to attain.

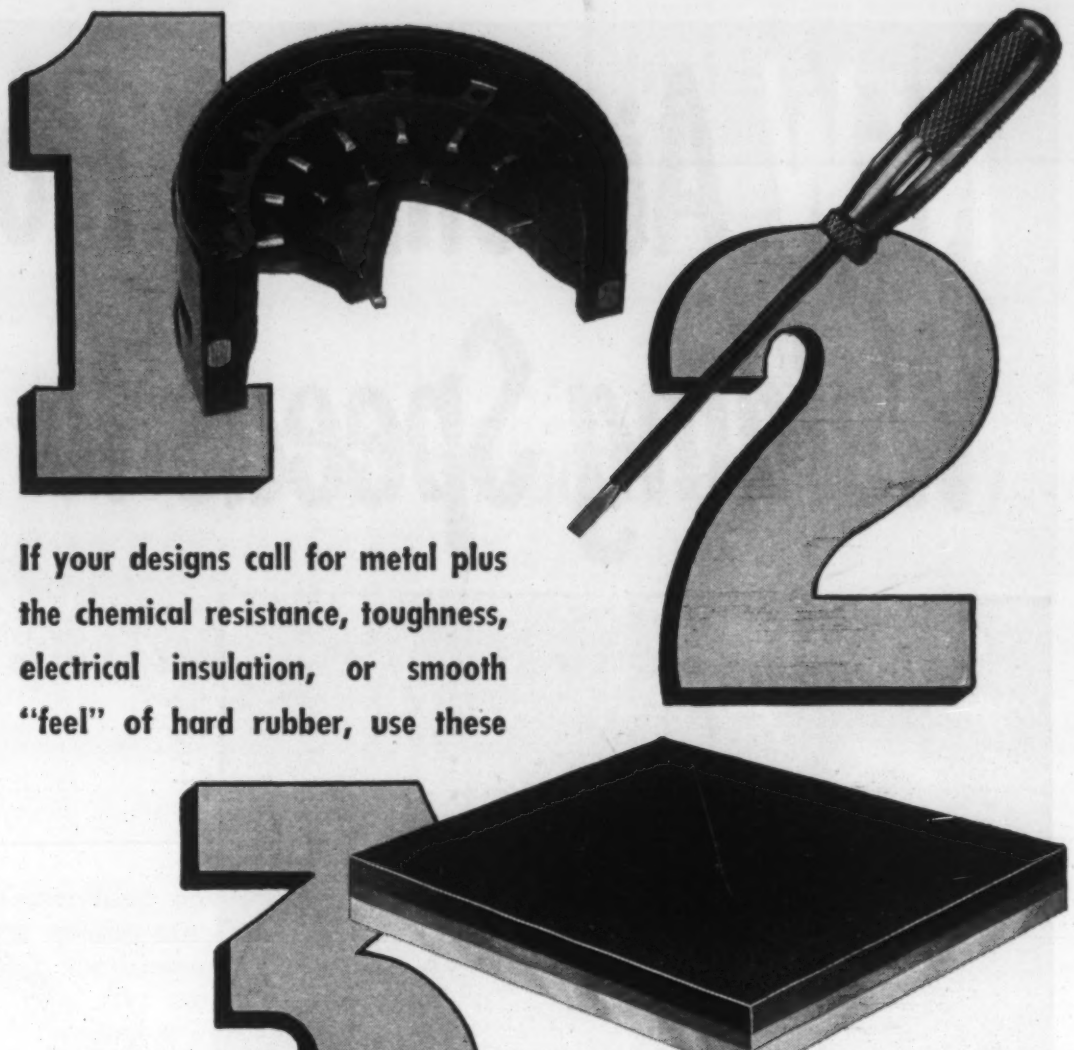
Development work is also underway on 20-mm practice projectiles made from powdered iron. The first samples were compacted to produce a density and hardness close to that found suitable for rotating bands, because one of the advantages of making this part from powdered metal rested in the ability to incorporate the rotating band as an integral part of the projectile body. However, these first projectiles were found unsatisfactory because the forces impressed on the projectile at the instant the cartridge fired were sufficient to compress the projectile lengthwise so that it swelled in the bore of the gun and the rifling marks were engraved in front of the rotating band. Other projectiles recently fired largely eliminated these difficulties and show greater promise.

Another possible application of metal powders lies in the production of armor piercing cores where the very heavy hard metals are used; but for the common type of hardened core made from steel, it is questionable whether either sufficient strength or density can be attained, or competitive production can be reached, as the caliber .50 size of this core is produced from bar steel on automatic screw machines ready for mass heat treatment in $3\frac{1}{2}$ sec.

Still another application might be some of the parts of the small fuses used in the 20-mm and larger calibers. Among the requirements which must be set for these parts are accuracy of dimensions, appropriate and consistent strength, and permanence of shape.

On the same subject of how pow-

(Continued on page 142)



If your designs call for metal plus the chemical resistance, toughness, electrical insulation, or smooth "feel" of hard rubber, use these

3 WAYS TO COMBINE HARD RUBBER AND METAL

1. *Molded Inserts:* Follow standard molding design practice. Magneto part above is good example. Seventeen inserts are molded into high dielectric Magnon Super Ace compound (dielectric strength 600 v/mil at 60 cycles). This Ace grade gives durable strength up to 300°F.

2. *Shrink Fits:* Screwdriver is insulated by slipping hard rubber tube softened in hot water over shank, then slipping heat-softened hard rubber handle over both shank and tube. Rubber cools, shrinks, gives positive-grip, insulated tool as no other material can do. An idea for you?

3. *Vulcanized Cement Bond:* Two-layer process: Hard rubber outer layer for best resistance to chemicals and aging; live, soft-rubber inner layer provides resilience. These Ace linings also can be all-hard or all-soft rubber, natural or synthetic.

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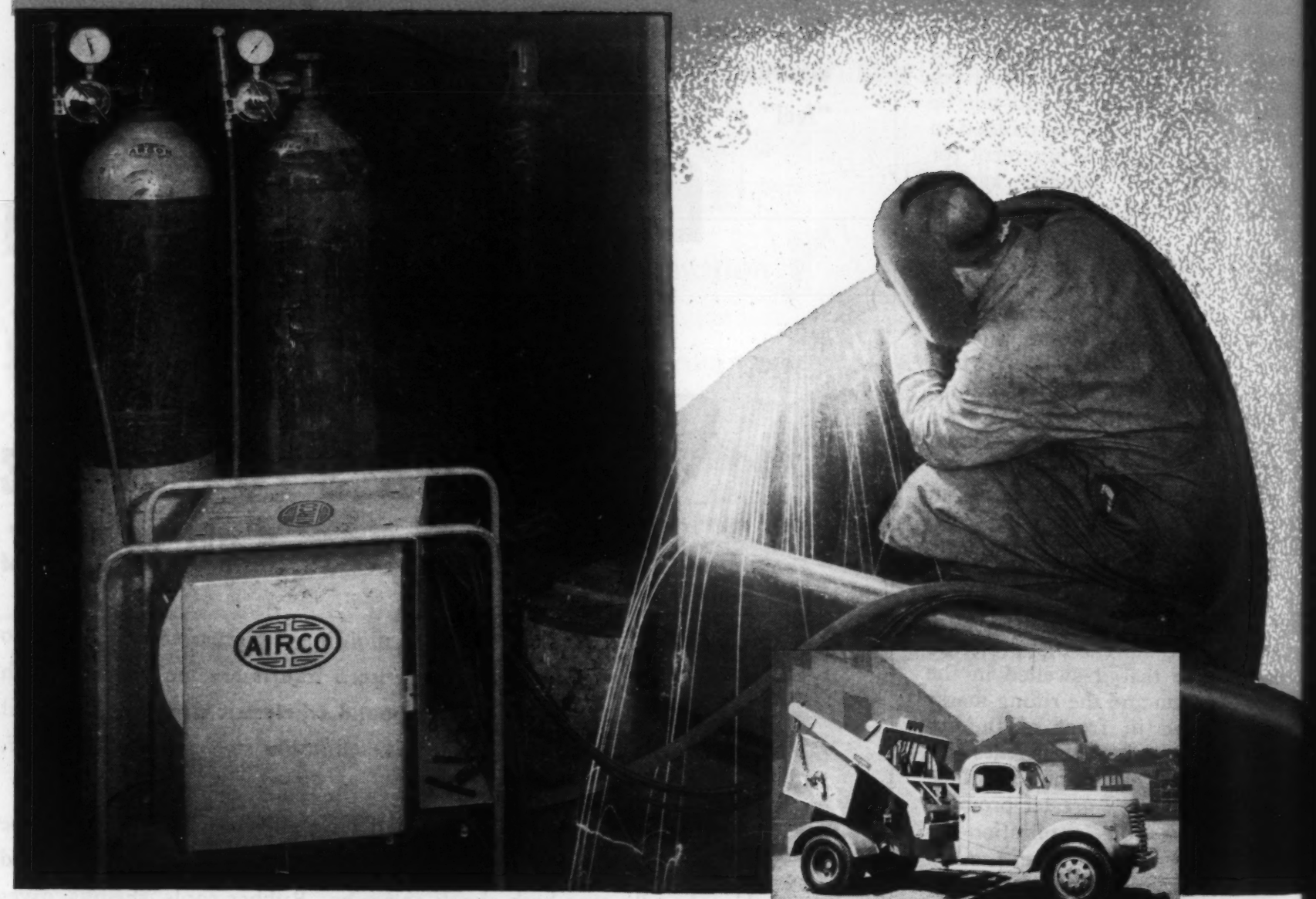
NEW Aircomatic® Process jumps Welding Speeds to NEW HIGHS



Aircomatic is a new metal arc welding process that permits high-speed welding of aluminum, of aluminum bronze and of stainless steel — *in all positions*..

The process uses a bare wire electrode in coil form, continuously fed to the work within an inert gas shield. High current densities are used providing excellent penetration and high deposition rates, *permitting welding at speeds greater than ever before possible.*

Aircomatic welding has proved most economical . . . for its high deposition rate, in addition to permitting high travel speed, also makes possible fewer passes on heavy material, and faster, heavier deposits for overlay or build-up work. This means more weld per unit of arc time, whatever the job. Further, since the wire is bare and continuously fed through a shield of inert gas, electrode changes and slag removal interruptions are eliminated, thus permitting almost 100% arc time in using the high operating speeds.

SAVES 16 MAN-HOURS WELDING TIME . . . Dempster Brothers Incorporated of Knoxville, Tenn., makers of the nationally known "Dempster-Dumpster" found Aircomatic welding cut their aluminum container manufacturing costs.

The other method was slow — cumbersome, and ran the cost exceedingly high. With Aircomatic the same container was produced — at a welding cost reduction of approximately 16 man-hours.

Another important feature of Aircomatic welding is its minimization of distortion. This is due to its high speed operation (heat can be concentrated and moved rapidly along the work), plus the fact that a small amount of weld metal is all that's required in most joints.

The case studies on the opposite page show how this dramatic new welding process is helping others. While the facts and figures are startling, they could very easily be applied in your own shop . . . but find out for sure. Write . . . or phone your nearby Airco office. Ask for a copy of ADR 66: "Aircomatic Welding Process".

Copper

— Our Current and Future Needs and Supply

by CHARLES A. SCARLOTT, Westinghouse Electric Corp.

While United States' mines are and will be producing large quantities of copper for many years, the hard fact is that the output does not meet present demand, much less a growing one.

• COPPER HAS HAD the dubious distinction of being among the first metals endowed with a government limitation order in the present defense repreparation program. On Nov. 29, 1950 the National Production Authority issued order M-12 that limited civilian usage of copper to a percentage of what was used during the first half of 1950. This was followed on Dec. 30 with a supplementary ruling prohibiting the use of copper in certain civilian products considered nonessential, such as specified plumbing fixtures, building materials, and ornamental objects. Production of television and radio sets in 1951 is being limited, among other things, by lack of copper. Full production of some electric-power equipment is no longer possible.

What is the meaning of this? Is the United States running out of copper? Or is there only a temporary inability of productive capacity to keep up with rising demand? Or is government stockpiling making an apparent deficit out of what would be a modest surplus?

Generalized answers to some of these queries can be given. For example, the United States has not run out of copper nor has it yet entered that inevitable period eventually reached with most minerals when production rate declines. The United States is running out of copper, of course, just as it is exhausting all nonreplaceable materials (except such things as magnesium). However, enormous quantities of copper still lie within our mountains and deep in our rocks. This does not say, however, that costs will remain the same as mines are required to work leaner or more difficult ores.

As to the ability of our productive capacity to meet demand, our nation turned from a copper exporter to a copper importer in the middle 30's, and it does not now seem likely that this country will ever again be a copper-surplus nation.

The government stockpiling of copper, obviously, has been an extra load on producers. How much is in the stockpile is not public information, but it has been estimated at 500,000 tons. This has been equivalent to 10% of production over the last five years.

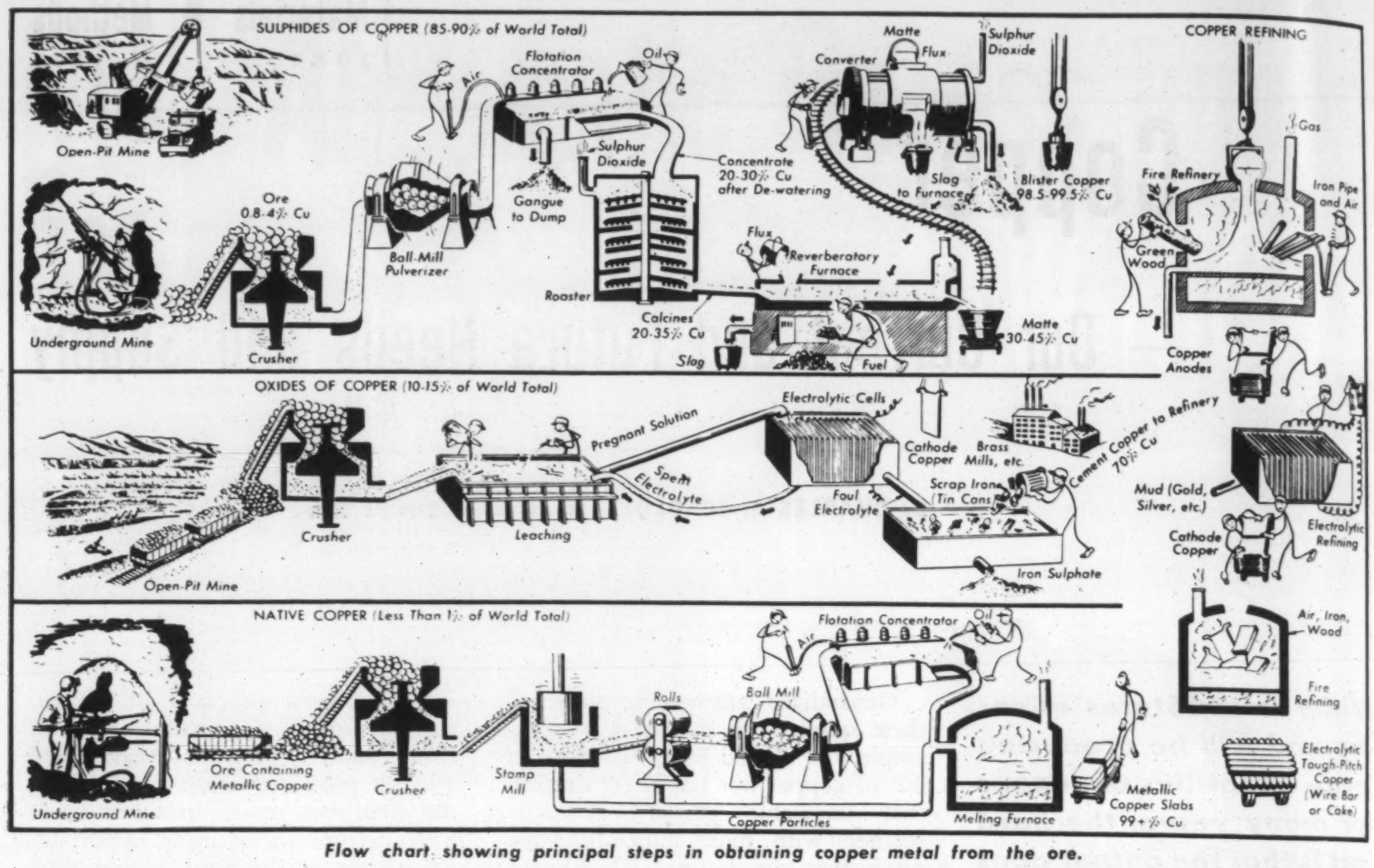
Generalized answers are nice but hazardous. It is better to set forth the essential facts and recent history of the industry from which conclusions and estimates of the future can be more readily formed.

Where Copper Comes from Now

The United States for the last century has been and is still the world's largest producer of copper, current mine production running about 900,000 tons per year. Until 1927 it produced more than half of the total but mines in other lands have become increasingly important. Four-fifths of the world's supply of primary copper (this side of the Iron Curtain) comes at present from five countries: United States, Chile, Northern Rhodesia, Canada and the Belgian Congo, in that order. (Rhodesian copper is not at present available to the United States as it is controlled by and customarily goes to firms in the United Kingdom.) These figures do not take into account Russia, which is believed to produce slightly more than the Belgian Congo, or at least one-fifth of United States production.

While these five countries are the major producers, copper comes from many places. The widespread occurrence of copper deposits throughout the world is indicated by the fact that the outputs of about 25 other widely scattered nations combine to make up the remaining fifth.

About nine-tenths of the world's known copper, believed to amount to approximately 100 million tons, lies in Chile, South Central Africa, Western United States, and Kazakstan (Southern Russia), and in that order. In quality the African deposits average best, about 3 to 6% copper; Chile, 2%; and United States mostly less than 1%. Except for Western United States and the big Chuquicamata pit of Chile, almost all important copper-ore bodies lie too deep for surface-mining methods.



Flow chart showing principal steps in obtaining copper metal from the ore.

Almost exactly half of the estimated world reserves (almost all in the United States and in Latin America) is mined by American companies. The British segment—Canada, Australia and Rhodesia—is about one-quarter of the whole, with Belgium controlling about 6% in the Congo.

Copper Production in the United States

In the United States copper comes principally from the Rocky Mountain region. Specifically, in order of rank, Arizona, Utah, Montana, New Mexico and Nevada. These five account for nearly 95% of the total, which in 1950 was 940,000 tons. In fact, Arizona and Utah contribute almost three-fourths of the United States total. Virtually all the other western states produce minor amounts. In 1949, Washington, California and Idaho combined to produce about 7500 tons, much of which comes about as a by-product of mining other metals, generally gold and silver.

Small amounts of copper come from states east of the Mississippi River. Little known is the fact that Tennessee has long been a producer of copper. Its output, with much smaller amounts from Missouri, Pennsylvania and Vermont, has been a fairly steady 17,000 tons yearly for many years.

The largest producer outside of the Western states is Michigan. The grade of ore runs about 0.9% copper. In about a century of copper mining Michigan has produced a little over 5 million tons, equivalent to about four years of United States consumption of new copper in 1949.

Michigan has prospects of improving its status as a copper producer. Consideration is being given to developing the very large White Pine ore body, where Michigan borders on Lake Superior. Unlike Michigan's previous ores, which have constituted essentially the only United States native-copper ore, the White Pine ores are sulfide ores. Furthermore, they are low grade—about 1.1% copper—and lie far too deep underground for low-cost surface-mining methods. It is estimated that nearly 3 million tons of copper can be recovered, which is equivalent to about two years present United States consumption.

Consideration is being given to opening up other deposits. One of these is the San Manuel underground ore body in Southern Arizona, which geologists estimate to contain 463 million tons of ore assaying 0.76% copper. Another important ore body lies at Yerington, Nev., believed to contain 50 million tons of 1% ore, recoverable by surface operation. The Greater Butte project is also low-grade ore, not mineable under earlier conditions. It lies above the 3,400-ft level in the Butte Hill mines that will be mined under a new plan. The ore body, previously passed over or untouched, is reported to contain about 130 million tons of 1.1% ore. At Bisbee, Ariz., a new open-pit mine is planned, which will require about 25 million dollars to develop. All these proposed new mines are sizeable low-grade deposits. Others are under consideration.

Forms of Copper Ore

Helpful to an appraisal of the copper picture are the essential facts as to the form copper ores take, in what amounts and degrees of richness, and their varieties.

Copper is a friendly metal. It is willing to combine chemically with many other elements. However, in Northern Michigan it is found alone—a situation unique in the United States. Only about 1% of the world's total is native copper. Occasionally it is found as large lumps—weighing several tons—but mostly as fine particles of copper dispersed through-

out hard rock that have averaged about 2% copper, although the grade is much less now. Before the decline of the Michigan mines 35 years ago, native copper ores played a major part in our copper supply. But these now account for but a small fraction of the output and are not expected to resume importance, short of an unlikely new discovery.

An appreciable amount of the world's copper—perhaps 15%—occurs as an oxide. There are nine varieties of these. Generally these lie on or near the surface, as they were originally sulfide ores that have been converted by exposure to oxygen and leaching with water and earth acids. Oxide ores are generally underlain or associated with larger bodies of sulfide ores. The oxide ores average about 1 or 2% copper, and are generally finely dispersed throughout hard rock.

Copper's favorite partner is sulfur. Copper sulfides comprise 75 to 80% of the world's copper ore. There are at least eight varieties but chalcocite (copper and sulfur) and chalcopyrite (copper, iron and sulfur) in about equal amounts account for the bulk of unmined copper ores. The principal remainder consists of combinations of copper with carbon, arsenic and antimony, although there are others.

About 70% of the United States total production of copper comes from the open-pit mines, which have obvious great advantages. The outstanding example of this is the fabulous open-pit at Bingham, Utah, begun in 1906 and operated by Kennecott Copper Corp. In the ten years from 1940 to 1949, inclusive, it has produced almost 2½ million tons of copper, more than 2½ times the next largest United States mine—Morenci, Ariz.—which is also an open-pit operation. It accounts for about 30% of the newly mined copper in the United States and approximately 10% of the world's reported primary production.

One characteristic common to almost all mining operations is the declining quality of the deposits worked. It is natural that the best deposits be used first. This certainly has been true of copper. A hundred years ago the average grade of copper being mined was 20%. In the 1914-1930 interval the average was 1½%. Now our largest copper producers—Bingham, Utah and Morenci, Ariz.—are running about 0.9%. The national average is slightly above 0.9%.

Price of Copper

The curve of copper prices resembles in profile the Rocky Mountain region from whence copper comes. Selling prices of copper have varied widely, indicating comparative sensitivity to demand. Copper production—all phases of it, mining, smelting and refining, but particularly mining—cannot be increased or decreased rapidly. Hence, the problem of relating world production to demand has been a serious one, with consequent wide swings in prices.

To predict the course of future copper prices would be folly, but some influencing factors are apparent. The general demand for copper is increasing—not to mention the superimposed defense-program needs. Copper generally is likely to be in short supply in the foreseeable years ahead. This is true generally for the whole world, not just for the United States. Hence, even removing the present 2¢ per lb excise tax would result in little if any increase in copper flowing into the United States, which is now about 400,000 tons per year.

Production in the United States is not likely to increase much for physical reasons. Even if new ore bodies are made productive—and that takes at least three years—the declining quality of ores will tend to offset the gains. On the other hand, mining technology has always steadily improved, which has the effect of lowering production costs. What governmental price controls, if any, will be established is another uncertainty. In general, however, rising copper prices, in the long term, seems inevitable.

United States Consumption of Copper

A review of copper statistics brings to light two significant facts. Mine productive capacity in the United States has remained substantially constant for the last 30 years. But the demand for copper has been generally upward, although it has suffered numerous sharp peaks and valleys.

If production peaks, which occur when the pressure of price or war demand is high, are taken as a rough measure of productive capacity, the results come out like this: 955,000 tons in World War I; 1,000,000 tons in 1929; 1,090,000 tons in 1943. Even a curve drawn to approximate average output starts at about 550,000 tons in 1910 and rises to only about 900,000 tons in 1950.

On the other hand, the total-use curve for new copper, as best it can be approximated allowing for peaks and valleys, rises from about 375,000 tons in 1910 to 1,441,000 tons (exclusive of stockpile) in 1950. It is difficult to trace the normal growth in demand for copper—because who can say what has been a normal period in the last 20 years? However, a study of 5-year averages since 1920, giving weight to the situation in each period, leaves no doubt about the increasing use in absolute amount and amount per capita (see table).

Furthermore, other factors favor a steadily increasing desire for more copper. Not only are old standby uses increasing, but also in the last several years new copper-consuming uses have appeared. An exact accounting of the end uses of copper is impossible. Perhaps the best indications come from data compiled by the American Bureau of Metal Statistics for the 1935-1939 period. On this basis the electrical industry (including telephone, telegraph and radio sets) takes a little more than half (54%), of which the manufacture of electric-power apparatus, home appliances and radio sets takes about half (or 28% of the total). The 40-odd million household electrical appliances built in 1950 used 100,000 tons of copper and copper-base alloys. The average refrigerator contains 20 lb of copper; a vacuum cleaner 4.5 lb. The high electrical conductivity of copper (only silver is better) obviously makes it the industry's basic metal (and will make more than minor substitution difficult).

Automobiles are the next largest user of copper, the amount running to about 13%, not counting the electrical system. Automobiles built in 1950 contain 137,000 tons of copper or copper-base alloy. The amount in an automobile lies between 40 and 60 lb. One small car contains 584 parts made of copper or copper alloy.

The building industry takes a similar percentage. The remaining fifth is divided among many uses, including bearings, valves, fittings, ammunition, wirecloth, etc.

In general, the things that normally use copper are—aside from war effects—on the increase. Kilowatthours consumed in the United States has, on the average, doubled every decade since 1910 and shows every sign of continuing to do so. The saturation level of automobiles

is not yet in sight. The building program is still far behind. It is calling for a large volume of copper, particularly for water pipe, gutters, downspouts, wire screen, and air-conditioning systems. Taken on any basis, the natural demand for copper can be expected to increase. The limit appears to be price and availability.

Scrap and Reserves

Fortunately, much of the copper used is employed structurally. Very little is incorporated with other products, as lead is with paint and antiknock fuel, where is it lost forever. More than three-fifths of the copper used is potentially recoverable. The amount actually recovered as scrap is highly variable, being responsive to copper selling price and labor supply.

In general, since 1925 output from old scrap (*i.e.,* from discarded materials that have served a useful purpose) has run to over 25% of the annual consumption of new and old copper except for the depression years when in one year it hit 49%, presumably because of the low cost of labor to collect it. (This does not include secondary copper from new scrap, *i.e.,* from clippings, punchings, etc. produced in the manufacture of copper products.) The amount of previously used copper that will return as scrap will undoubtedly greatly increase. It is quite possible that the amount of scrap copper will exceed the new copper for limited periods.

When a mineral becomes difficult to obtain, a natural question is: How much reserves do we have? In the case of copper a good solid statistical answer is impossible to give. It probably wouldn't be worth much anyway. The real pay-off question is: To what extent and for how long can the United States supply its own copper needs? This involves a great deal more than dividing some estimate of copper-ore reserves by the annual rate of use to obtain a figure for the number of years before copper bankruptcy.

A definite figure of copper-ore reserves is almost meaningless, for several reasons. For one thing, no such figure is published. The nearest approach to one is that compiled by the Federal Trade Commission in 1945 of 29,220,000 tons (of copper). To this should be added some 10 million tons of reserves not included in the 1945 estimate. Since 1945 some 4 million tons of copper have been mined, and we are currently producing at almost a million tons per year. If you wish, you may interpret this as 25 to 30 years worth left. But almost no one—in the industry or out—lays much stock in such a number. As one mining engineer succinctly put it, "Figures for copper reserves have a remarkable habit of remaining substantially constant." A U. S. Bureau of Mines bulletin in 1938 gave a figure of 26.2 million tons of unmined copper in the United States.

Reserve figures are indefinite, for good reasons. For one thing, exploration — involving extensive core drilling—is expensive. But the greatest single factor is the difficulty of deciding today what ore is practicable of mining 20 or 30 years from now. Most copper now comes from workings that mining men snubbed 30 to 40 years ago. Mining methods—particularly for the handling of large tonnages — have improved to the point that ores as lean as 16 lb of copper per ton are profitable. How much farther improved technology will carry this trend no one can say with surety. Certainly if ores another point or two lower in richness can be considered workable, an enormous quantity would be instantly added to our "reserves".

Furthermore, leanness of ore is not the only factor. The price paid for copper has an obvious direct effect on what can be considered workable reserves.

Location of ore body is also important, as it determines the mining method. Depth of overburden, or depth of shaft, and so on, with margins close, may be controlling. Local situations—not enough or too much water—or presence or absence of other minerals have a bearing on whether an ore body can be counted as workable. About all that can be said is that the total amount of copper in lean, uncounted ore bodies in the United States is very large. Copper can be had from it—at a price.

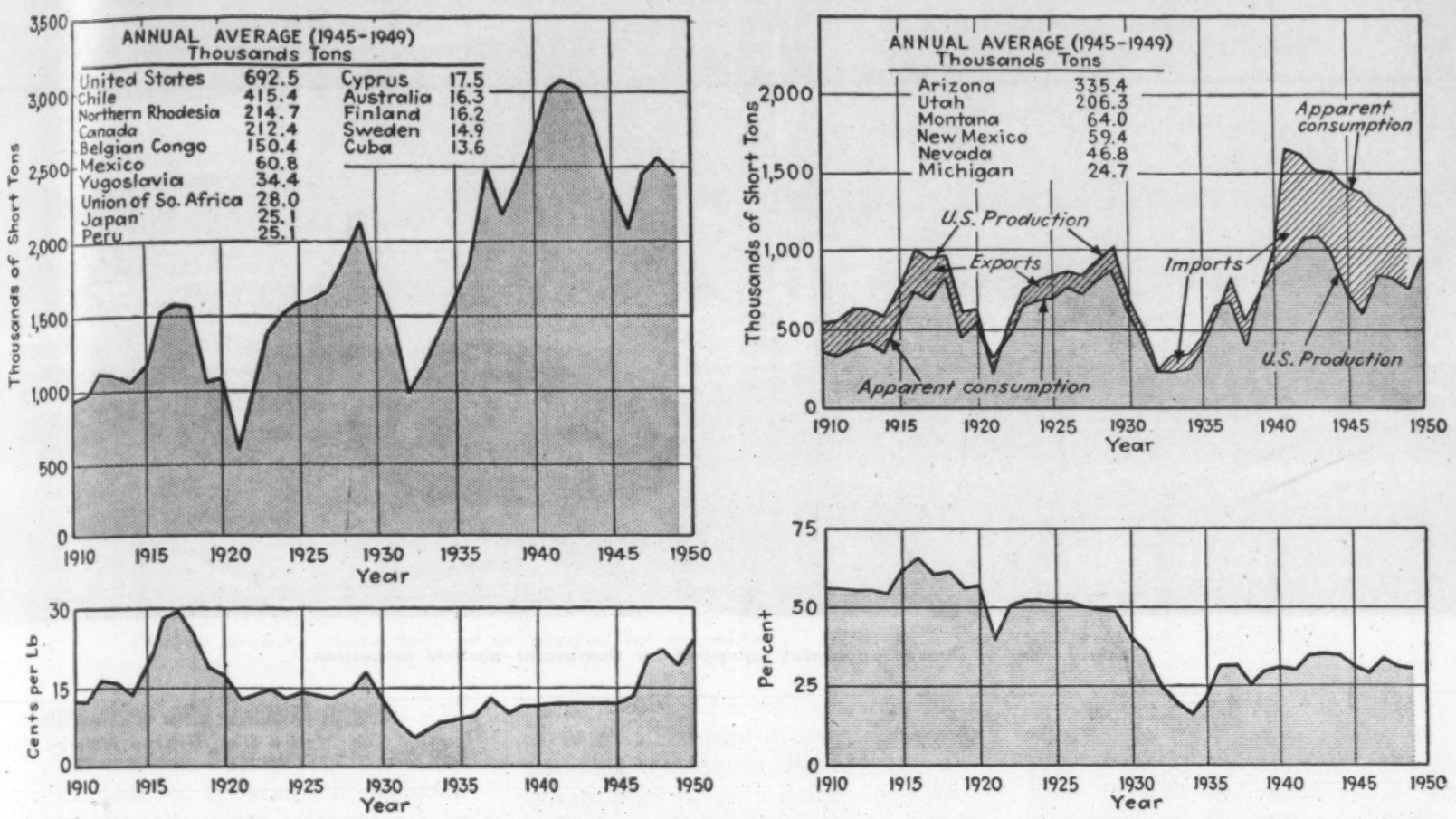
The chances of stepping up the rate of copper production by any large factor to supply the growing demand are not good. Although operations in new ore bodies—such as White Pine, San Manuel or Yerington—may be opened up, it will be at least three years after the decision is made in each case before any copper results. It is not feasible to step up operations at existing mines by a large factor. The mining plant—stripping, shovel, railroad facilities, concentrator plant—is established for operation at a certain closely coordinated rate. Operation at any much different rate is costly. A further factor is the very real difficulty of obtaining additional manpower when industrial-plant job possibilities are large (and more attractive in pay and other perquisites), and the military demand is great.

The mines are not, of course, the only factor in increasing copper output. As the chart of the steps from mine to fabricator shows, other major facilities are necessary in the series, principally smelters and refining plants. Additional ones could be built, however. As of 1950, smelter capacity stood at 9,450,000 tons per year. There are 12 active refineries in the United States, with a total capacity of 1.5 million tons per year (1950 refinery output = 1.25 million tons, of which a fourth originated in foreign ores).

Domestic copper mines have had a

United States Average Consumption of New Copper

Period	Average Yearly Consumption, Thousand Tons	Consumption, Pounds per Capita
1921-1925	556	9.87
1926-1930 Prosperity Period	764	12.71
1931-1935 Depression Period	361	5.76
1936-1940 Post-Depression Recovery Period	696	10.70
1941-1945 World War II	1226	22.42
1946-1949 Postwar Recovery Period	1192	16.55



Upper left: world production. Upper right: U. S. production and consumption. Lower left: price. Lower right: per cent of U. S. production to world total.

strong price incentive to produce at a maximum rate during the last four years. Actual production averaged 860,000 tons. Maximum production during World War II, with incentives very great, exceeded 1,000,000 tons only twice (1,100,000 average for 1942 and 1943). It does not seem likely, therefore, that the industry is capable of producing more than about 900,000 tons per year for a sustained period.

Can We Do with Less?

When any material becomes hard to get or more costly, or both, engineers are forced to consider a naturally distasteful proposition — substitution. If this happens to copper, what are the prospects in the electrical industry? In short, not good. Not soon, anyway.

Where copper is used for nonmagnetic or corrosion reasons, the problems are not as serious as when electrical conductivity is involved. The only practically possible substitute for electrical conductors is pure aluminum, which for a given cross section has about 61% of the conductivity of copper. Thus, for the same current and voltage drop the aluminum member would be (theoretically, not necessarily actually) about 1.5 times larger in dimensions but would weigh only about half as much, the weight ratio of copper to aluminum being about 3 to 1.

If aluminum were freely available —which it isn't—the first relatively easy move the electric-power industry could take would be to substitute aluminum for bus bars where space is not a critical factor. Such a change would save a lot of copper, probably several thousand tons yearly. This would involve more than putting in aluminum busses where copper ones were used before. There are recognized problems of low-drop connections and extra bracing where forces under short circuit are high. (Aluminum, for the same cross section, is not as rigid as copper.) But these matters are not regarded as insuperable.

But suppose aluminum had to be used for conductors in rotating machines, transformers and other devices. What then? It can be done, with an increase in cost and dimensions. Insulation would be a problem. Some work has been done with synthetic and cotton covering for aluminum wire. However, efforts to enamel aluminum have not been blessed with overwhelming success. Probably it can be done, but certainly new techniques will be required.

Having obtained suitable insulated aluminum wire, redesigns of almost all apparatus using it would be a certainty, because of the size factors. Also, soldering and other types of connections pose problems, although they are probably not impossible of solution.

Substitutes for copper are being aggressively explored. Some shifts will be necessary, probably long range as well as middle range. It is too early to be more definite about substitution for copper in individual applications except that it is on the way in many instances.

However, any conclusion that copper will join the buffalo is not sound. Copper was the first important metal used by man. It can be counted on to be an increasingly useful servant for centuries in the future. There is a lot of copper in the world, but it is not inexhaustible. We must learn to use it wisely and without waste. That makes sense, anyway—and not only with copper.

Information for this article was provided by the staffs of the U. S. Bureau of Mines, U. S. Geological Survey, American Bureau of Metal Statistics, the *Daily Metal Reporter*, the Copper and Brass Research Assn., American Smelting and Refining Co., American Metal Co., Anaconda Copper Mining Corp., Kennecott Sales Corp., Phelps-Dodge Corp., and Westinghouse.

This is the first of a series of articles on the status of our critical engineering materials. Nickel and cobalt, tungsten and molybdenum, lead and zinc will be covered in future articles.

General view of Duovec apparatus equipped for fluorescent particle inspection.

All photos courtesy Electro-Motive Div., General Motors Corp.

New Magnetic Particle Testing Technique Speeds Inspection of Ferrous Parts

by S. G. KELLEY, JR., Materials & Methods

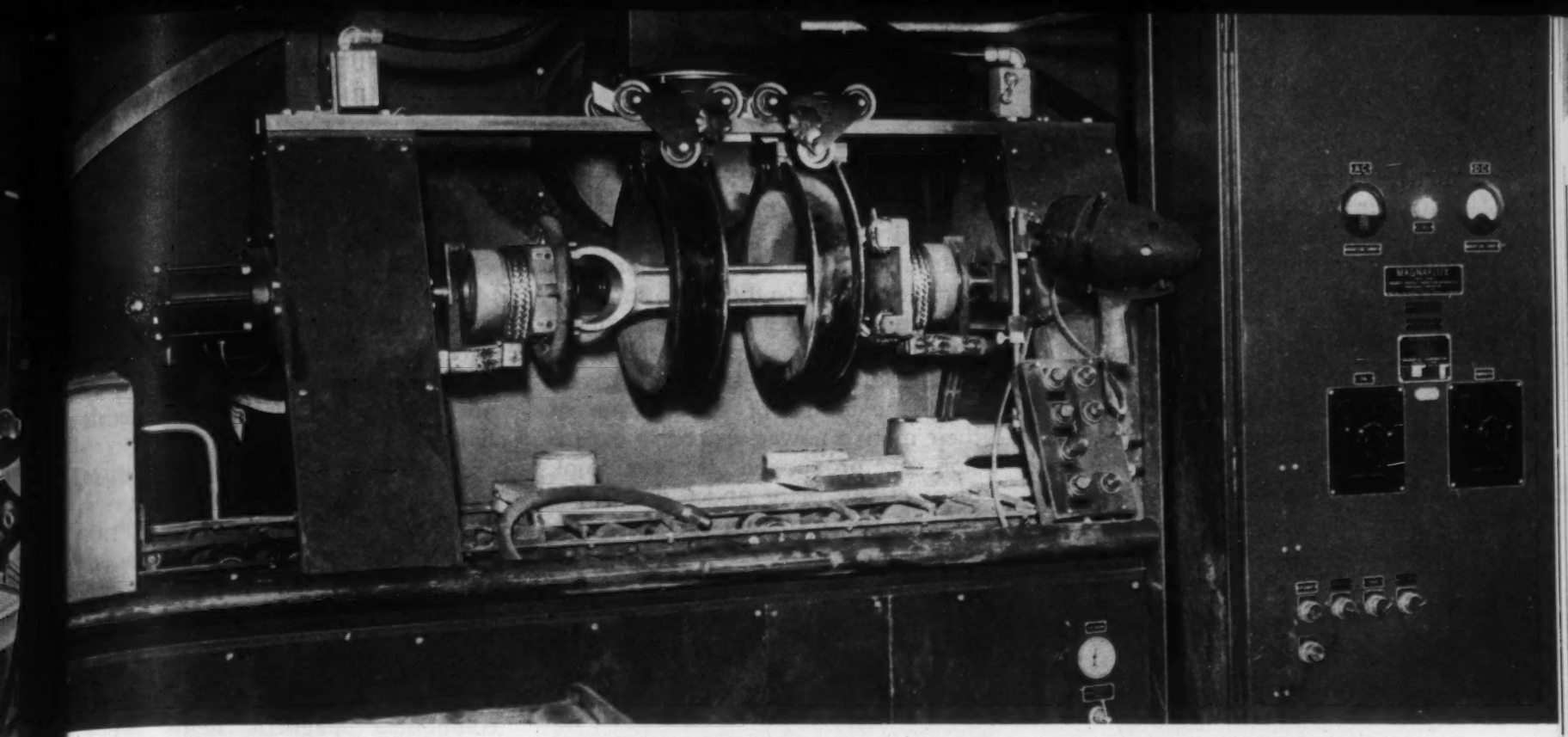
Modified magnetic particle inspection method detects surface defects occurring in any direction in one operation.

• A NEW TECHNIQUE of magnetic particle inspection has been introduced by Magnaflux Corp. which enables ferrous parts to be inspected for surface defects in all directions in one operation. Known as Duovec, the technique is not only considerably faster than the conventional Magnaflux technique, but in many cases, has improved sensitivity.

Basically, the Duovec technique involves the use of a moving magnetic field that magnetizes the part under test in many directions. It thus makes possible the location of defects in any direction in one inspection operation. This is a considerable improvement over the older Magnaflux method, in which the part is ordinarily magnetized in only one direction at a time. Thus, for 100% inspection, the separate application of static fields at right angles to each other is required, whereas the same amount of inspection is accomplished by the Duovec technique with one magnetization and in about half the time.

The Duovec equipment resembles that of the conventional Magnaflux method in many ways. Electrical contact heads set up a circular field in the part and another device, usually a coil, produces a longitudinal field. These can be modified to permit a more thorough magnetization of oddly shaped parts. Jet engine compressor blades, for example, might require the use of a coil around the blade, a set of electrical contacts for putting a current through the blade lengthwise, and a second set to create a strong field in the root of the blade which might not be sufficiently magnetized were it to depend only on the coil and a single set of contacts. In order to produce the moving field, Duovec requires a power supply that provides two or more different currents simultaneously. The combined currents set up magnetizing forces essentially at right angles to each other and so timed as to produce a moving field in the part.

While magnetized, the part is usually sprayed with fluorescent magnetic particles which have been found effective in the location of even the smallest defects. It is then inspected under black light and sent on its way as a good or rejected part.



Closeup showing connecting rod in position for magnetizing. Note use of two coils, position of contact heads.

Capabilities and Limitations

The sizes and shapes of parts for which Duovec apparatus is designed vary with the users, at present. In general, it is most effective on small parts that handle easily. Large, awkward parts unsuited to production line handling do not fall into the Duovec realm of inspection but are generally examined using local magnetization on the areas most likely to be defective.

Where applicable, the new method essentially cuts inspection costs in half through savings in man-hours. One man can now inspect a part completely in half the time required using previous techniques. Efficient materials handling made possible by the Duovec technique greatly contributes to the savings in time and cost. One inspector can inspect a part completely with minimum handling, and no detour is necessary to a separate inspection location where space must be allotted to pile-up parts awaiting their turn in an inspection slower than the operations of the production line.

Closely related to the reduced inspection time is the fact that an inspector can examine many more parts using Duovec before becoming fatigued. Tests conducted by the manufacturer show that considerably fewer defects are overlooked.

The Duovec technique enables the discovery of the same types of defects as standard Magnaflux techniques. It is most useful for discovering surface defects, such as laps, surface inclusions, porosity, cracks of various types and seams, and is also successful in the location of certain sub-surface defects near to the surface.

In theory, Duovec's moving field gives an advantage in sensitivity over standard techniques. Because the optimum position of a defect for detection is perpendicular to the magnetic field, Duovec, with its field moving through an arc, is ideally equipped to locate defects aligned in many directions. The two statically positioned fields of Magnaflux, on the other hand, will be perpendicular to defects aligned in only two directions. As yet, insufficient data have been collected for a conclusive statement on the greater sensitivity of Duovec, but the manufacturer does claim that the new method is at least as sensitive as the older one.

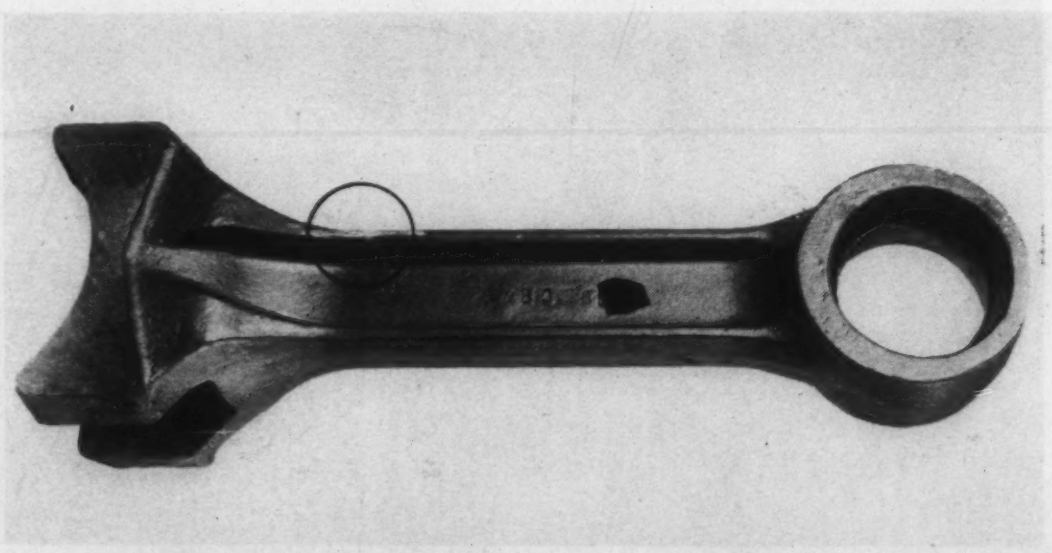
The limitations of Duovec are generally those characteristic of magnetic particle inspection methods. It can only be used to examine parts made of magnetic materials and will not be applicable to any others. There is, however, one specific limitation of the Duovec technique. As a moving field method of inspection, it is especially adapted to the total inspection of a part. If inspection is required for defects in only one direction, its advantages over Magnaflux are likely to be eliminated entirely and a higher first cost incurred.

A Typical Application

As an example of the high production use of Duovec, the experience of one user gives a good idea as to how effective it can be when applied to the production of parts for diesel locomotives.

The long life factor and high quality requirements of the diesel engine in a diesel electric locomotive has long dictated the use of magnetic particle inspection as one of the ways of controlling the raw material and processing quality of certain engine components.

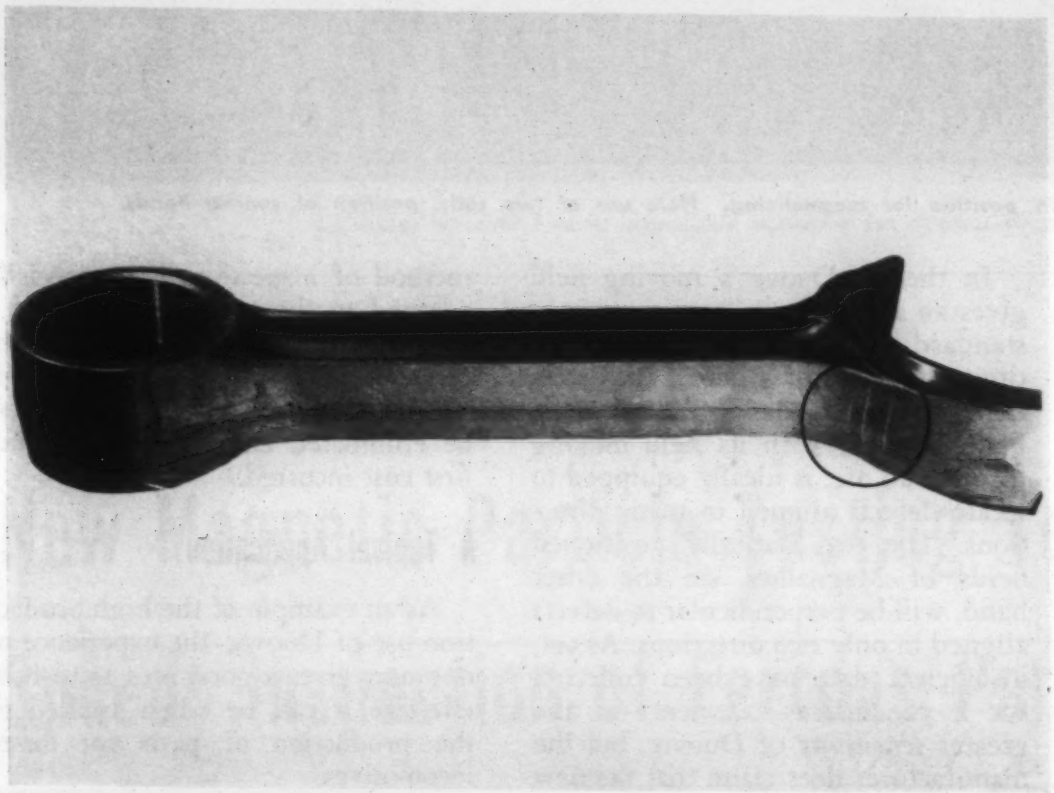
Two of the most important parts used in the 1500-hp diesel engine are



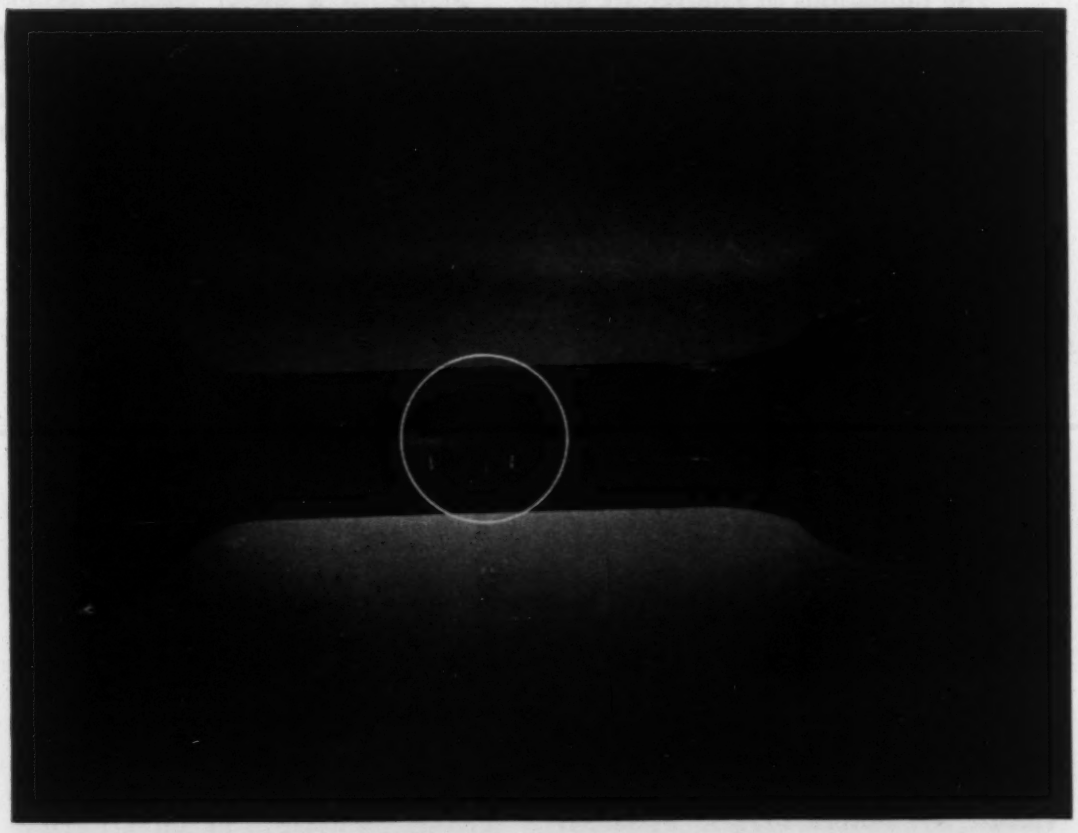
Forging fold revealed by Duovec in a fork-type connecting rod under white light.

the fork type and the slipper type connecting rods. These parts, made from heat treated alloy steel, are among those inspected by magetic particle testing. Formerly, the first stage of this test was made by clamping a part between contact heads and passing the current through it to create a circular magnetic field for disclosing longitudinal defects. The second step was to energize the part while it was positioned within a coil in order to develop a longitudinal magnetic field for revealing transverse defects. The inspections were made successively using a wet, continuous method. A later development was the introduction of the fluorescent particle method to these two stages of inspection in order to provide a more sensitive check on a production basis.

As the American railroads accelerated the tempo of dieselization of their motive power, extensive expansion of production facilities took place at the plant under discussion. Due to the increased schedules improved methods were needed. After investigation, one of the changes introduced was to change to the Duovec technique for testing the two types of connecting rods.



Straightening crack revealed by Duovec under ordinary light.



"Black light" photograph showing straightening crack revealed by Duovec using fluorescent particle method.

This technique was chosen because it replaced the two-stage inspection procedures above described by a single stage inspection of greater sensitivity and also enabled better materials handling.

The Duovec machine used consists of a work table with heads between which the part is clamped. Direct current is transmitted from the contact heads through the part, resulting in a circular field of magnetization. Simultaneously, an a.c. current is passed through a coil surrounding the part.

The vector field resulting from the component magnetic fields swings through a varying angle. As this occurs, the magnetic forces at some time during the cycle exist at right angles to discontinuities in the connecting rod and result in maximum sensitivity of defect detection. The fluorescent particle inspection fluid is flowed over the part simultaneously with the magnetic energization.

The operating cycle is as follows:

1. Bring the part on a conveyor pallet into position.
2. Press the "lift" button to actuate the hydraulic lift for positioning the part between heads.
3. Press the "clamp" button to grip the part between clamping heads. (The hydraulic lift now retracts automatically.)
4. Position the coils around the work.
5. Press the "energizing" button and simultaneously flow magnetic particle inspection fluid over the part.
6. Retract the coils and inspect the part with black light. The heads rotate freely so that all portions of the part can be closely examined.
7. Press the "lower" button, which brings the lift up to lower the part to the conveyor pallet.

The controls are so interlocked as to safeguard the inspector from any malfunctioning of the machanism due to inadvertently following the wrong sequence of operation.

The introduction of this semi-automatic unit having Duovec energization and black light (fluorescent magnetic particle) inspection medium has improved the sensitivity of the inspection; has combined circular and longitudinal magnetic particle inspection into one operation; and has paced the inspection operation to the production line, thereby eliminating "float" and trucking to a central inspection area.

Questions and Answers on the Controlled Materials Plan

Here are the answers to many of the pertinent questions you have been asking about CMP, which begins July 1.

by T. C. DU MOND, Editor

• EVEN THOUGH MANY PEOPLE in industry today had experience with the Controlled Materials Plan of World War II, there are enough differences in the new CMP to cause many questions to arise. On these two pages, some of the most important questions are answered.

CMP officials point out emphatically that manufacturers will only hurt their own cases if they attempt to pad their needs in applying for controlled materials. A sincere attempt is being made to assure an equitable division of available materials. False figures will throw needs out of balance and will usually cause harmful delays on individual applications.

For those who seek additional information on CMP we suggest a visit to the nearest regional office of the Department of Commerce, where copies of the regulations and interpretive literature can be obtained. One of the most helpful pieces is a little booklet known as the "ABC's of CMP".

Question: What is the Controlled Materials Plan?

Answer: The Controlled Materials Plan is a system intended to make certain that materials essential to the military and civilian economies are distributed as equitably as is possible.

Question: When does the CMP go into effect?

Answer: CMP goes in operation July 1 and will cover allocations of materials for the third quarter of 1951 and subsequent quarters.

Question: What materials are controlled?

Answer: Copper, aluminum and steel are the only materials now covered by CMP.

Question: Does the CMP override previous regulations issued by the National Production Authority as far as the use of materials is concerned?

Answer: No. Even though materials may be available after all essential uses are taken care of, the surplus cannot be used for products and processes unless such uses comply with NPA regulations covering those materials.

Question: Is there any classification of products under CMP?

Answer: Yes. Products are divided into "A" products and "B" products.

Question: On what basis?

Answer: "A" products are special products with only one, or relatively few uses. Most military products fall into this group, as would special designs of products bought by one or two customers.

"B" products are those of general design which can be used by many customers both military and civilian. Standard electric motors would be an example of this classification, as would ball bearings, automobiles and thousands of other items in everyday use.

Question: Are all products covered by the CMP at the start?

Answer: No. Many products such as automobiles, refrigerators, cook stoves and electrical appliances are not required to file applications at the present time.

Question: How do I determine whether I must file for our product?

Answer: Consult the "Product Assignment Directory and Official CMP Class B Product List" issued by CMP and available through Department of Commerce Field Offices.

Question: What CMP regulations have been issued and what do they cover?

Answer: Five regulations have been issued and two more are forthcoming:

CMP Reg. 1 defines the CMP and its operation and establishes the authority.

CMP Reg. 2 covers limitations of inventories of controlled materials.

CMP Reg. 3 establishes preference status of delivery orders.

CMP Reg. 4 regulates the delivery of controlled materials by distributors.

CMP Reg. 5 provides for maintenance, repair and operating supplies.

CMP Reg. 6 will explain how to get materials for construction.

CMP Reg. 7 will provide for the obtaining of controlled materials by repairmen.

Question: Explain how a producer of an "A" product operates under CMP.

Answer: Assume the company has a contract to make a specified number of tanks. His first step is to total all materials needs of his company, plus those of sub-

contractors making special products for this contract. Total materials needs plus production schedules are then presented to the claimant agency. (Agency placing tank contract.)

This order's needs are then totalled with other needs of the agency and presented to CMP as the total needs of that agency.

After the total of all materials requirements is determined, the agency is informed as to how much of its claim has been allowed. The proportion is then passed on to each company participating and the company is given an authorized production schedule, an allotment of controlled materials, an allotment of number, and a DO rating to procure "B" components and materials such as rubber and tin that are not under CMP.

The prime contractor passes along its allotment and DO rating to its suppliers of "A" products so they can get needed materials and "B" components.

Question: What about "B" products?

Answer: Manufacturers of "B" products total the materials required under proposed production schedules and submit their applications to their industry groups as indicated in the Product Assignment Directory.

Question: How are products identified?

Answer: The Products Assignment Directory provides a code number for each product classification. This number must be used on all applications and in any correspondence concerning CMP allotments.

Question: Are detailed breakdowns of materials required?

Answer: Only so far as quantities of a given form are concerned. The application must show how many tons of sheet, bar, castings, plate, extrusions, etc., will be needed.

Question: Where are decisions on allotments made?

Answer: Applications are approved, downgraded, or turned down, as the case may be, by the Industry Division or Claimant Agency involved. The requests are then passed on to the proper Controlled Materials Division for final allocation of materials.

Question: Are separate applications required for each product made by one company?

Answer: If all products fall within one product class the answer is no. However, a different CMP-4B application must be filed for each separate product class produced.

Question: Are users of small quantities of controlled materials exempt from filing under the CMP?

Answer: You need not apply if you use less than 5 tons of carbon steel; ½ ton of alloy steel; 500 lb of copper and copper-base alloys; 500 lb of aluminum; and no stainless steel. If all requirements are below these minimums, no application is required, but if needs for any one material exceed the minimum, applications are required for all of the controlled materials. Uses cited are in any one quarter.

Question: In the instruction sheet for CMP-4A Form in Section III, Column (a), we are told to include the material required for forgings, but in items 17 and 32 in Section III of the form it says: "Do not include forgings." Where should forging requirements be shown?

Answer: Applications should include the rough stock weight required for forgings in the shape of billets or bars in Items 17 and 26 on the application form. Weight of finished forgings is not required.

Manufacturers of this selected group of "B" products using steel, copper or aluminum must file applications covering anticipated needs for CMP materials.

Agricultural machinery; construction and mining machinery; oil field machinery; machine tools, metal working machinery and accessories, including welding and cutting apparatus; steam engines, steam and hydraulic turbines; pumps and compressors; conveyors and conveying equipment; elevators and escalators; fans and blowers, industrial; industrial trucks and tractors; mechanical power transmission equipment; heat exchangers, condensers, packaging machines, centrifugals and separators; hydraulic jacks and lubricating devices; motors and generators; switch gear and electrical control apparatus; electrical welding apparatus, including electrodes and welding rods; ships and vessels; locomotives; railroad and street cars; tractors; tin cans; fabricated structural steel products; tanks, boilers and cylinders; stamped and pressed metal products; valves and fittings; antifriction bearings; food products machinery; textile machinery; woodworking machinery; paper making machinery; printing and publishing machinery; special industrial machinery; aircraft and aircraft parts; truck trailers; metal shipping containers; screw machine products; industrial furnaces and ovens; mechanical stokers; office machines; scales and balances; commercial laundry and dry cleaning machinery; measuring and dispensing pumps and lubrication equipment; commercial service equipment except household types; electrical wiring devices and supplies; electrical indicating and measuring instruments; lighting fixtures; steel springs; bolts, nuts, rivets and other industrial fasteners; collapsible tubes; internal combustion engines; transformers; capacitors, rectifiers, induction and dielectric heating units; electrical accessory equipment for internal combustion engines; electric lamps, incandescent and fluorescent; radio, radar and television equipment, except home type; radio tubes; telephone and telegraph communication equipment; storage batteries; primary batteries, dry and wet; x-ray and therapeutic apparatus; motor vehicles, except passenger type; small arms; small arms ammunition; cooperage; partitions, lockers and shelving; window and door screens; restaurant furniture; paperboard boxes; fiber cans, tubes and drums; periodicals; books; cutlery; edge tools; hand tools; files and rasps; hand saws and blades; other hardware; plumbing fixtures; oil burners; heating and cooking equipment, except residential; metal doors and sash, frame, etc.; sheet metal products, such as roofing, culverts, etc., except awnings and radiator enclosures; scientific and surveying instruments; mechanical measuring and controlling instruments; optical instruments and goods; dental, surgical and medical instruments and appliances; photographic equipment; clocks and watches, etc.

Thin, Attractive Metal Coatings Produced by Vacuum Method

Aluminum is most widely used for vapor metallizing nonmetallic materials such as plastics, glass, fabrics and paper.

by **KENNETH ROSE**, Western Editor, Materials & Methods

Molded plastics decorated by vacuum coatings include automobile horn buttons, escutcheon plates, religious articles, and novelties. (Distillation Products Industries)

• WHEN A METALLIC surface must be developed on a nonmetallic material, the engineer has a choice of several methods. By applying an electrically conductive film to the nonmetallic material, it can be made conductive and suitable for electroplating. For some purposes, simple laminating with metal foil and an adhesive bonding agent will be satisfactory. Spraying with a mist of molten metal from a metallizing gun is a method widely used, and one that provides for quick buildup of a substantial thickness of metal in a short time. In a few applications where wear resistance is not needed, a metal paste can be applied like paint and fused into nonmetallic surfaces. In some cases, metal can be deposited chemically, as in the silvering of mirrors. Another method, not new but recently widened in scope, is the process of vacuum coating.

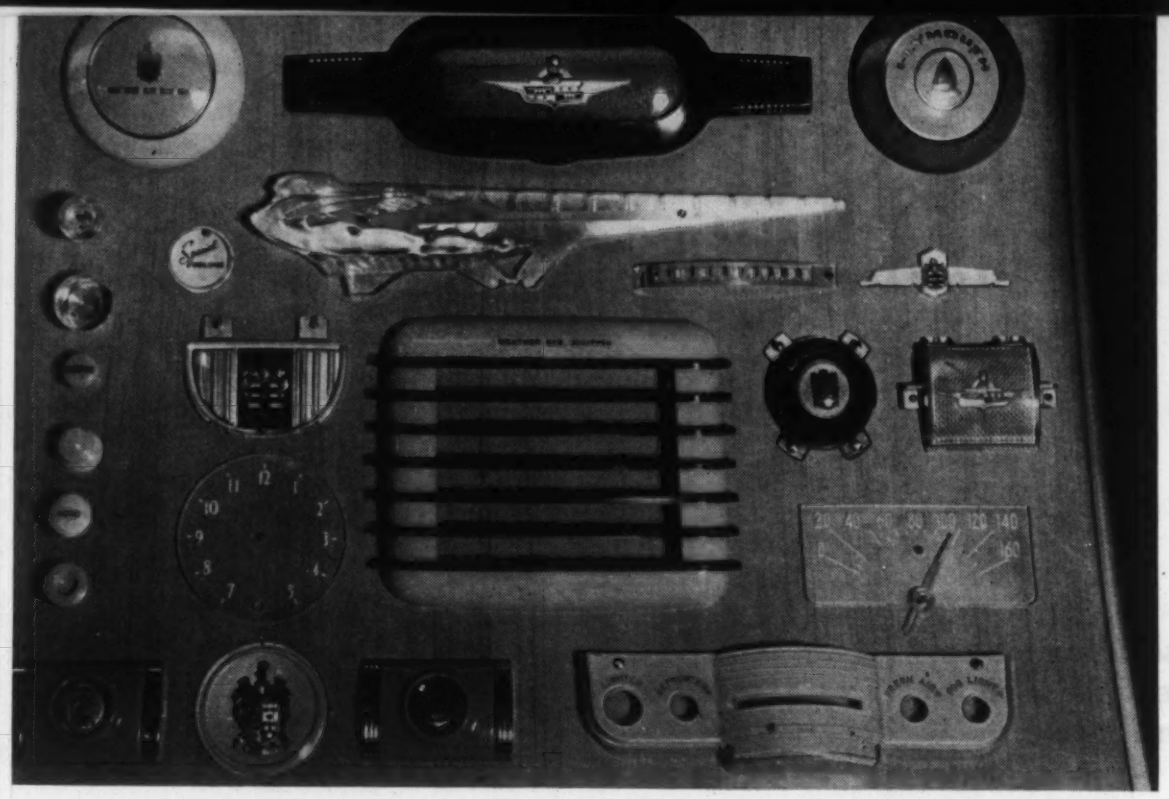
Coating of nonmetallics with a metal film in a vacuum is one of the simplest of procedures. The pieces to be coated are suitably arranged in a container, in which a small wafer or wire of the metal to be applied is attached to a small loop of tungsten wire, and air is exhausted from the container to high vacuum. An electric current is then passed through the tungsten loop, heating it to incandescense and vaporizing the metal wafer. The vaporized metal is deposited on the surfaces of the pieces in the container.

The vacuum coating process is not strictly limited to the coating of nonmetallics, nor to the applying of metals to the parts to be coated. One of the important uses for the process is in the coating of optical lenses with an anti-reflection film of a chemical compound, usually magnesium fluoride. Metal can also be deposited on other metals, though the limitations of the process are such that this is not frequently done.

Most of the vacuum coating other than that of optical lenses consists of the application of a metallic film to a nonmetal, and the metal most commonly applied is aluminum. Aluminum vaporizes easily, is tarnish-resistant when deposited, and is low in cost. Other metals that can be used for vacuum coating include gold, silver, chromium, nickel, zinc and Inconel.

The equipment consists of a container for the work, which can be a bell jar for a small unit, or a metal vacuum chamber for larger installation; vacuum pumps, usually of the diffusion type, to exhaust the air from the container to a vacuum of one-tenth of a micron of mercury; one or more electrodes holding the heaters or filaments used to evaporate the coating metal; and the necessary power supply and control gages. Special devices, such as heaters for continuous vaporizing of metal, and a winding mechanism to permit rolling and unrolling of strips of stock during continuous coating, can also be a part of the machine. Special trays or racks to hold the pieces to be coated to best advantage can also be used.

Pieces for vacuum coating need not be cleaned unless obviously soiled, or unless they have been handled. Development of a bright, adherent film of metal requires a vacuum of a high order, however, and pumping equipment must be of a type intended for such use. For rapid evacuation of air



Shown here are a variety of automotive decorative parts vacuum metallized by The Electric Auto-Lite Co.

from the vaporizing chamber, a roughing pump can be used to remove most of the air, with the oil diffusion pumps to carry the vacuum to the desired limits. To avoid contamination of the film, the vacuum must be taken to a pressure of 1 micron of mercury at most, to 0.5 micron preferably, and to 0.1 micron for best results.

Advantages and Disadvantages

Some of the features of the process are:

1. The deposited film requires no extra handfinishing. As deposited, it is usually of a brilliant sheen, without the need of polishing or buffing sometimes needed to bring out the best luster in electroplated pieces.

2. The process fits into production setups well. It is rapid, the equipment can be had as a reasonably compact package, and there are no messy operations or trade wastes.

3. The material requirements are simple. For aluminum coating, ordinary 2S, commercially pure aluminum, is used, and quantities needed for even large operations are insignificant.

4. Colors can be obtained, by dyeing the film, by masking and paint spraying for contrast, or by overcoating with colored lacquer.

Limitations of the process include:

1. Materials to be coated must have low vapor pressure. If the base material tends to "boil", or to give off vapors under high vacuum, vapor deposition cannot be used successfully. Actually, this limitation rules out wood and certain other natural materials, and certain formulations of plastics having volatile plasticizers, but permits use of plastics, metals, cloth, glass, paper, mineral crystals, etc. The vacuum must be lowered to one-tenth of a micron of mercury, and any vapor from the work that prevents reaching this figure will hinder operations.

2. The metallic film is very thin. It may be only 0.00001 in. thick. This means that it will (a) have practically no abrasion resistance, and so must be protected against even ordinary handling; (b) be unsuitable for any touchup operations, such as polishing; (c) be inadequate as a substitute for electroplating; (d) have practically no covering power as far as defects in the base material are concerned.

3. Vapors travel in a straight line in a vacuum, and the work must be carefully arranged for coating.

4. The work must be of a size that can be placed inside the vacuum chamber. As chambers can be obtained in large sizes for use in horizontal position, this is seldom a serious limitation.

Applications

Applications of vapor metallizing are diverse enough to indicate the broad usefulness of the process. It was used nearly two decades ago to produce the metal surfacing on glass mirrors for reflecting telescopes. Paper has been coated with aluminum by vaporizing to produce a wrapping material that will substitute for the expensive laminated paper foils. Quartz crystals have been metallized for electronic applications. Work has been done on metallizing of cloth to provide heat reflectance.

Some of the most widely used applications of vacuum coating with metals are in the plastics field. One reason for this is that metallizing the under surface of a transparent plastics material will permit the luster of the metal to show to best advantage while protecting the metal film from abrasion. The automotive industry has adopted metallizing so generally that today there is not a single standard make of car that does not have parts ornamented by this method. Horn buttons, instrument panel escutcheon plates, trunk escutcheons, side decorative plates, pushbutton door openers, etc., are produced in clear and colorless plastics, frequently acrylics, molded to artistic designs and ornamented by coloring and metallizing.

The pieces are given an attractive multicolor treatment by molding the design in the clear material, then spraying one or more colors into the cavity in the molded piece, with electroformed or other tight-fitting masks

Television mirrors are metallized at Westinghouse by vacuum deposition methods.

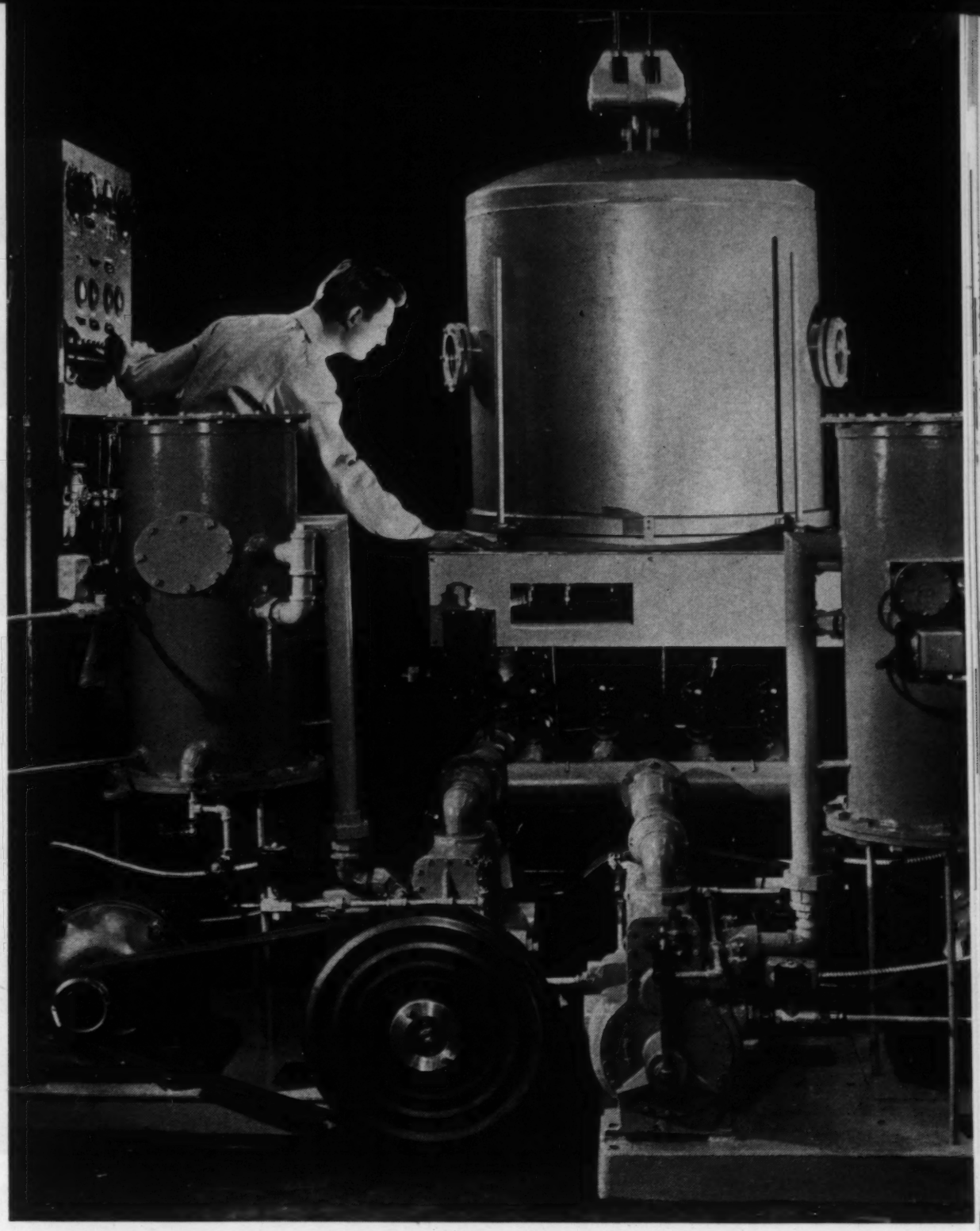
to block out the areas to show the metallized finish, and to block out the colors one at a time in multicolored designs. The cavity is then metallized by vaporizing aluminum into it, the aluminum showing through at the clear areas of the plastics material with the sprayed color for contrast. Both metallizing and coloring are done on the underside of the plastics piece. To protect this undersurface it can be given an overcoat of paint or other protective finish to back it.

Plastics pieces made for the novelty and other low-priced outlets make use of another technique, called second-surface coating. Such items as novelties and toys, tuck combs, and costume jewelry are molded in clear or opaque plastics, frequently polystyrene. To keep down costs, the molds are not highly polished. Scratches and other imperfections are first covered over by giving the molded pieces a lacquer coating. This fills out scratches, but does not hide them. After thorough drying, the pieces are metallized to impart a bright opaque finish, and a second lacquer coat is then applied to protect the metal. The metal coat itself, while opaque, would not have sufficient thickness to fill out any of the scratches, so the development of the second surface is necessary. Color can be imparted to the pieces by using a tinted lacquer for the second coat, applied over the metal finish.

Another standard item for metallizing that uses a special technique is the ornamental sequin for women's clothing. These were formerly punched from heavy foil. They are now made by metallizing acetate film 0.0075 in. thick, then punching out the sequins on quick-acting punch presses. The first sequins made by metallizing plastics film used silver for the metal coating, but aluminum is used now. The acetate film is placed in the metallizing chamber on a roll, and aluminum is continuously vaporized as the film is wound from one roll to another inside the chamber.

The same technique of continuous metallizing of a moving web of material is used for metallizing heavy paper to be used for wrappings. It is also used for metallizing pressure-sensitive tapes, the metal film being applied before gumming. A recent application has been the metallizing of bolts of Saran fabric to be used as seat covers in movie theatres. The metallized seat covering has been found to have sufficient reflecting power for light to be visible in the dimly lighted theatre.

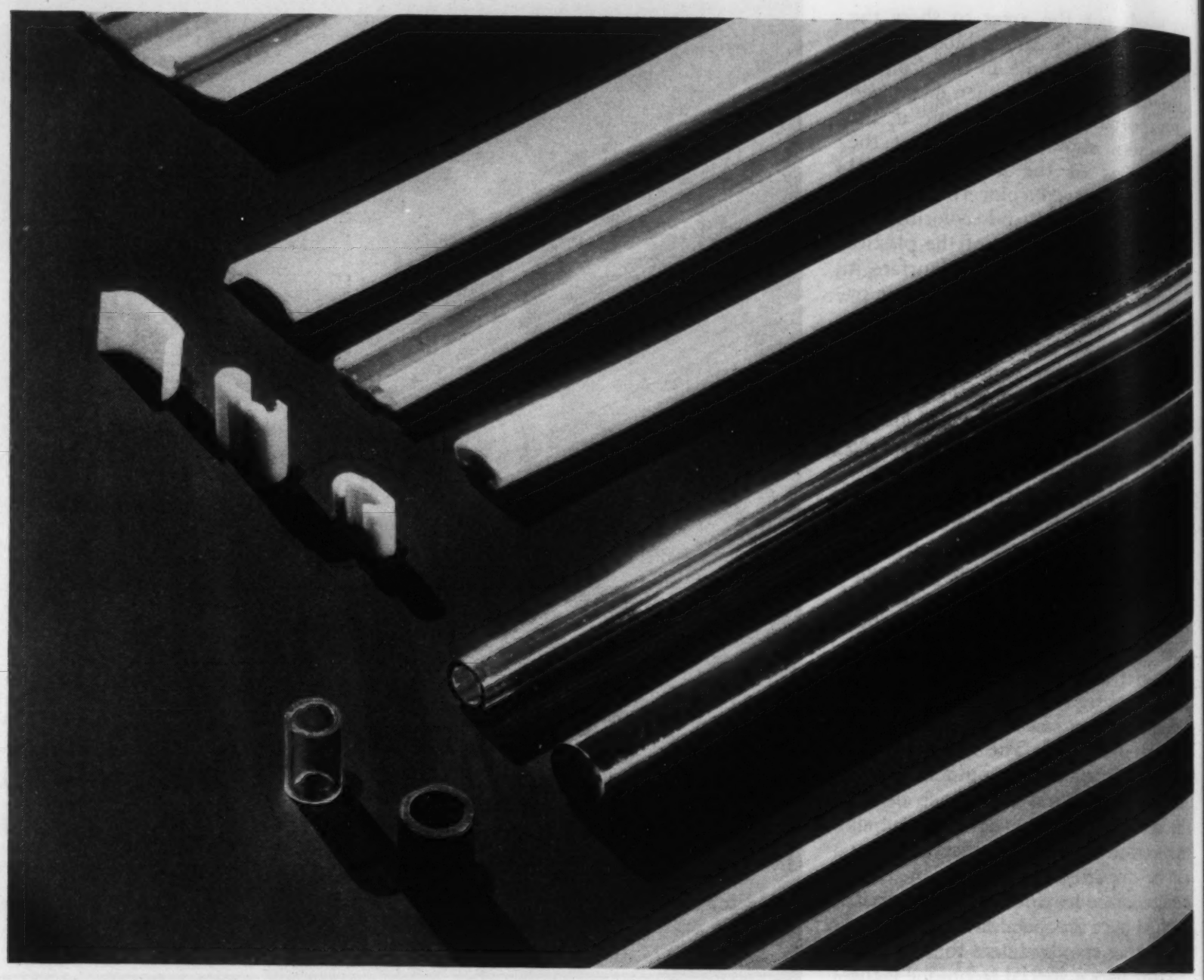
As the vaporized metal travels in a straight line from the point of vaporization to whatever object it impinged upon, it is sometimes necessary to provide means of positioning irregular work, or of changing its position, during the metallizing operation. Such pieces can be held in jigs, and rotated for coating on all sides. Spectacle frames are metallized in this manner.



Vacuum coating equipment can be compact and easily controlled. (Distillation Products Industries)

Metals other than aluminum can be used for vacuum coating. Gold-plated jewelry is sometimes prepared by vaporizing the metal in the same manner as was described for aluminum, especially when the piece contains recessed portions not easily reached by electroplating. The film of gold so laid down is not thick enough to be very durable, so it finds its biggest use in this field as an auxiliary coating method, to reach parts of the work where electroplating or other deposition method is not very effective. Chromium and nickel can be deposited similarly, but the films are too dull to be ornamental, and too thin to contribute to the surface hardness. Silver is sometimes applied to ornamental pieces and to costume jewelry, for which zinc die castings can be a base. Both gold and silver are used in the coating of religious objects. Zinc deposited onto heavy paper has been used to replace the metal foil-and-paper piles used in small capacitors. Films of metallic gold so thin as to be transparent have been laid down on glass to form heat-reflecting lenses for fire-fighting suits. Films of Inconel deposited over glass lenses reduce the transmission of ultraviolet light, and find a use in sun glasses.

With proper equipment, vacuum coating is an economical means of depositing a very thin film of metal on a nonmetallic surface, giving it a brilliant metallic luster to add to its attractiveness.



Plastic Extrusions Cut Costs in Recent Applications

Many plastic shapes and parts can be produced most economically by extrusion, a process which has been gaining rapidly in recent years.

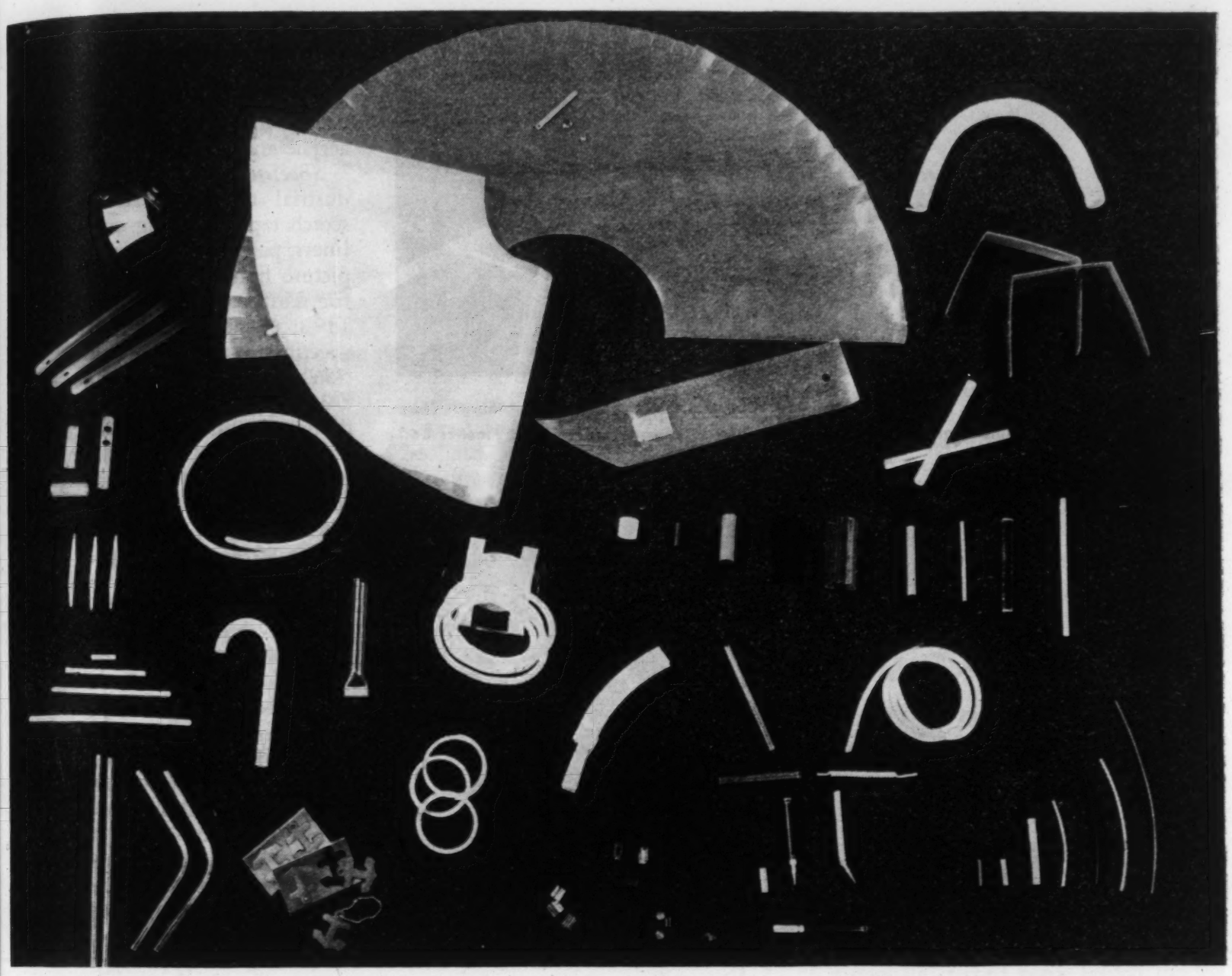
by **WILLIAM SCHACK***

• PLASTIC EXTRUSIONS are formed by forcing the hot material through a die opening of the desired shape, in the same way toothpaste is pushed out of a tube. The plastic comes out in a continuous ribbon, which takes the shape of the die opening.

There are two forms of the process —wet and dry extrusion. In the wet method, a solvent is added to the raw material to give greater plasticity than can be obtained with heat alone. Cellulose nitrate, casein rods and tubes, and strain-free polyvinyl butyral sheeting for laminated safety glass are wet processed. The unqualified term *extrusion,* however, is reserved for the dry, continuous process which has developed rapidly in the last ten years and is now much more widely used than wet extrusion.

The material, usually in pellet or granular form, less often as a powder, is fed into the cylindrical barrel of the extruding machine. This cylinder is heated by electricity in most machines so that closely controlled temperature zones are set up along its length. A rotating screw homogenizes the plastic, conveying it along

*Editor, *"A Manual of Plastics and Resins, in Encyclopedia Form".*



Small parts can be fabricated from extrusions by cutting, bending, punching and heat-sealing. (Anchor Plastics Co.)

the cylinder and forcing it out through the die orifice. The shaped extrusion ribbon is then carried through air, water or some other cooling medium by a takeout mechanism, and cut to length.

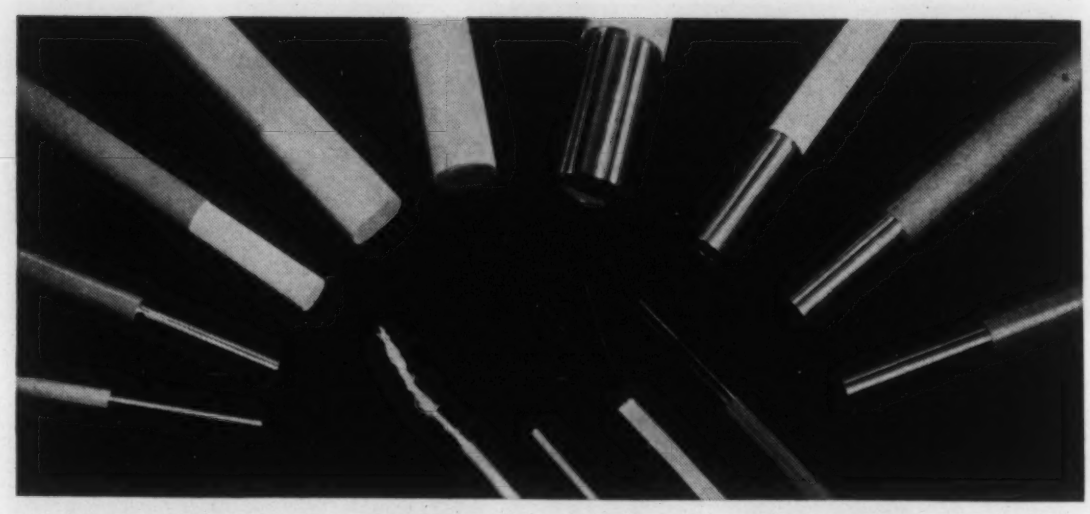
In order to maintain a smooth surface and close dimensional tolerances in the finished extrusion, the raw material must have a uniform particle size and a low controlled moisture content. The temperature at each section of the cylinder must also be held constant if a good extrusion is to be obtained. The production rate can usually be increased by preheating the plastic before it is fed to the extruding machine. In considering the use of one machine for several materials, however, it should be remembered that while an electrically heated machine with a number of independently controlled heating and cooling zones can be used with many different plastics, optimum dimensional uniformity and production rates can only be obtained when the depth and the pitch of the screw flight in the machine are designed specifically for one particular plastic.

Although thermosetting phenolic pipe has been extruded in this country and in England, the bulk of the material processed by extrusion at present is thermoplastic. The thermoplastics used commercially include acrylic, cellulose acetate, cellulose acetate butyrate, ethyl cellulose, plasticized polyvinyl alcohol, polyvinyl butyral, polyvinylidene chloride (Saran), polystyrene, polyethylene, silicone rubber, nylon, polytetrafluoroethylene (Teflon) and polytrifluorocholorethylene (Kel-F). Each material has its own optimum extrusion temperature, ranging from 200 up to 800 F.

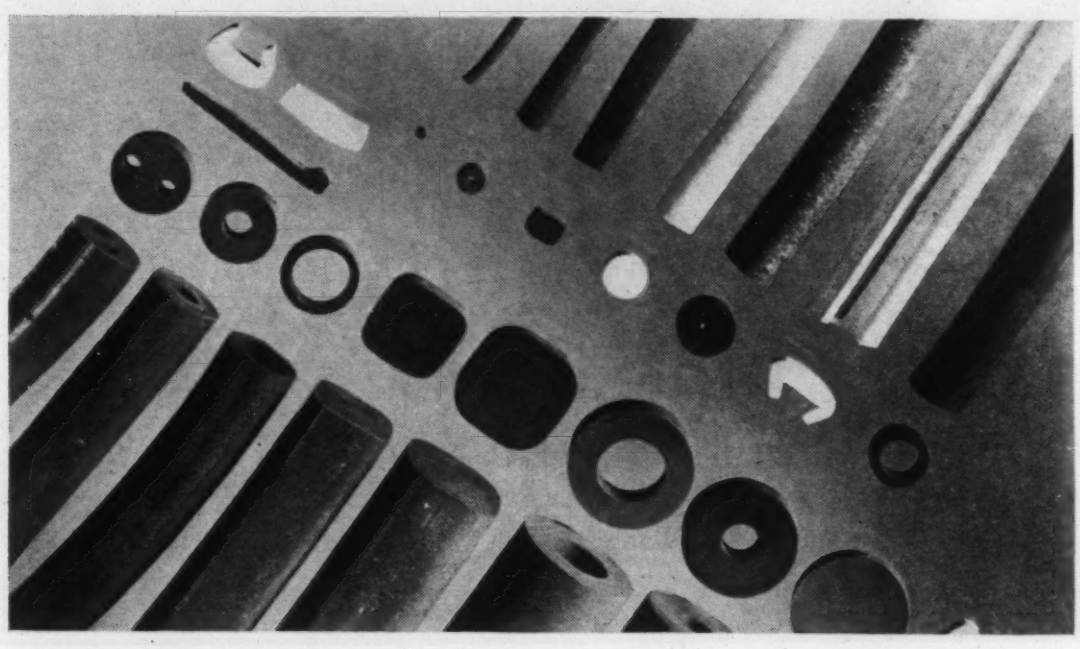
Available Forms

Plastic extrusions are manufactured as tubing, rods, sheeting, flat strips, profiles, filaments, and coatings for wire, cable, pipe and rope. Most extrusions are used in these forms, simply cut to size, although more complex parts fabricated from the basic extruded shapes are coming into more general use all the time.

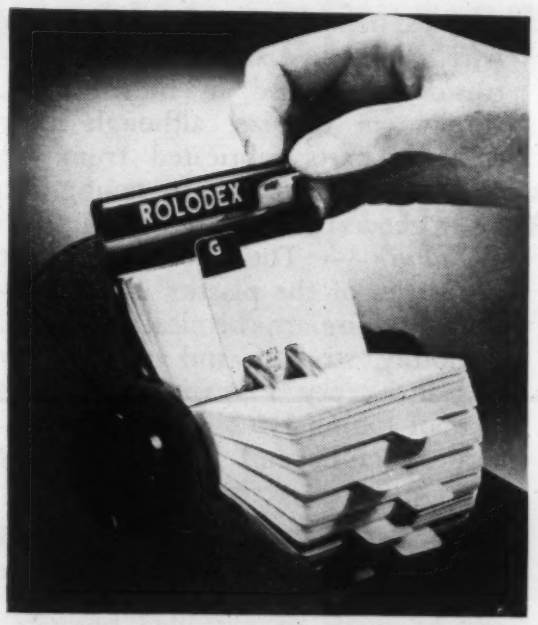
Tubing — The most important properties of the plastics used in extruded tubing are chemical resistance, flexibility, strength and transparency or translucency. Plasticized polyvinyl alcohol tubing is used for low pressure hydraulic and lubrication lines because of its resistance to organic solvents, which attack other rubber-like compounds. Beer, syrup, vinegar, distilled water and irrigation lines can be made of extruded butyrate; polyvinyl chloride is suitable for some of the same applications. Saran tubing gives a wide temperature range at high bursting pressures, and polyethylene tubing finds diverse applications from beer dispensing to hot nitric acid lines. Kel-F and Teflon



Extrusions over metal wire, rod and pipe, and rope are, in effect, plastic tubing. They serve as electrical insulators and as decorative and protective coatings. (Anchor Plastics Co.)



Silicone rubber gaskets are cut from such extruded shapes as tubes, rods, channels, and modifications of these forms. (General Electric Co., Plastics Dept.)



The functional nameplate of this rotating file is a channel extruded in black butyrate by Anchor Plastics Co. for the manufacturer, Zephyr American Corp. Attachment to the sheet metal plate is simply by pressure fit. (Tennessee Eastman Corp.)

are in a class by themselves, of course, for high chemical resistance at elevated temperatures.

Metal fittings can be used with most of these materials, but polyvinyl chloride sleeves are often satisfactory, and a full line of molded Saran flare-type fittings has also been developed. A spot-welding technique has proved effective for joining heavy sections of polyethylene pipe.

The commercial range of diameters and wall thicknesses in extruded plastic tubing has been greatly extended in the last two years. One manufacturer, for example, offers diameters from 3/32 to 16 in., with wall thicknesses from 0.0015 to 0.250 in. Another produces polyethylene tubing as small as 0.250 o.d. with a 0.20-in. wall thickness. Some extruders and jobbers carry plastic tubing in stock; others produce it to order from special or stock dies.

Rods — Acrylic, acetate, butyrate and polystyrene are the plastics most commonly extruded in rod form. These rods are used for light load supports—in racks, for example—and for decorative applications which utilize the light-piping property of acrylic and polystyrene.

Sheeting—The manufacture of industrial tapes, electrical insulation, scotch tape, shipping containers and liners, packaging, safety glass, motion picture film and mold release agents for reinforced plastics has promoted an accelerated demand for plastic sheeting. Extruded sheeting production is growing in volume since it is cheaper than cast sheeting, although the cast product is reported to have greater clarity and uniformity of thickness, somewhat superior physical properties for a given gage, and better flexibility of formulation.

Flat Strips—The simplest form of extrusion, flat strips, are used in making belting, straps, insulation, labels, handles, shields, washers and trim. Some fabrication is often involved.

Profiles—Perhaps the richest and most diversified field for plastics extrusion is in profiles, since most of the profile shapes that are extruded cannot be made by any other process. The design possibilities are extremely broad, including U, T and curved shapes, with various additional projections and smooth, ribbed or fluted surfaces. One extrusion manufacturer shows 127 dimensional drawings in his catalog, merely to suggest the possibilities. Parts for refrigerators, automobiles, airplanes, office appliances, furniture, musical instruments, architectural trim and industrial equipment are made from extruded channels. One of the chief virtues of parts made from extruded plastic profiles is the simplicity of assembly to other parts—the resiliency of the plastic usually makes a snap-on fit perfectly adequate.

Filaments — Synthetic fibers are made up of one or several filaments produced by dry extrusion, or more commonly, by solution extrusion, through spinnerets. The most important dry-extruded filaments are the vinyl chloride-vinylidene chloride copolymers and vinylidene chloride-acylonitrite copolymers, used for bristles, filter cloth, screening and upholstery. The high tensile strength nylon fabrics and bristle and the acetate fabrics are familiar examples of other extruded plastic filament products.

Coatings—Extruded plastic coatings find application as insulation on various kinds of wire. Vinyl coatings are used on general-purpose wire

carrying up to 600 v, polyethylene on high-frequency wire and cable, and nylon on magnet wire. Jacketing applied to conductors for secondary insulation and mechanical protection, as well as the coatings on pipe stanchions and display racks, are made by extruding plastics.

Fabricating Extrusions

Extrusions can be cut to size and finished by the same fabricating methods used with molded thermoplastic parts. Cutting, punching, shearing, forming, routing, hot stamping, machining, grinding, drilling, threading and tapping can all be done on extrusions. They can be assembled by solvent bonding or mechanical means like any thermoplastic parts. Rigid butyrate tubing cut to size and mounted with self-tapping or regular screws has been used as a television tube stand-off insulator, and in the recently developed Forman insulating screws, the plastic extruded over a metal rod is threaded and individual screws fabricated by the usual methods. Insulating sleeves are also fabricated from extruded polyethylene film by cutting the material to shape and heat-sealing to form the finished part. Much of the commercial importance of coated metal pipe depends upon its ability to be formed to desired shapes in conventional pipe-bending equipment, without damaging the outside plastic surface.

Of considerable design interest is a toy clarinet which used two extruded components. The body, an extruded tube, was punched at intervals to receive the metal key assembly, which was then riveted in place. The second extrusion was a shallow channel, thickened at the bottom for rigidity, which conformed to the curvature of the body tube. This channel was also punched out to provide air vents for the reeds. The reeds were riveted to the brass reed plate, which was inserted into the channel and held in place by a simple force fit.

Extruded acrylic and polystyrene rods are bent, twisted and shaped for display products. In the fender-protecting light for automobiles put on the market some time ago, a clear acrylic rod cut to size served to pipe light to a colored, flame-like molded acrylic cap.

Extrusion Properties

The extrusion process has been developed to the point that uniform dimensions and close tolerances can be held. The figures in the accompanying table are cited by the Sandee Manufacturing Co. as average commercial tolerances. As this manufacturer points out, however, closer limits can be maintained at the price of higher costs and lower production rates.

Plastic extrusions have the same physical properties as molded pieces of the same material. Like molded parts, they are economical when mass produced, light in weight, and often simplify product assembly by allowing the use of single part in place of several pieces required with other materials. The relatively simple dies used in extrusion cut the tooling costs for this process down to a figure unattainable with injection, compression or transfer molding. A typical extrusion die may cost from $60 to $85; even complex dies run no higher than about $250.

Actually, the set-up time to adjust the die to deliver properly is the most important cost factor on any extrusion job. This set-up cost makes short runs uneconomical. The real economy of extrusion begins in runs taking at least 500 lb of material; if a piece weighs ½ oz, it takes an order of 16,000 units to reach low unit cost.

An interesting possibility for economy is the use of extruders in place of injection molding machines with suitable parts. This is, of course, confined by the nature of the extrusion die to certain fairly simple shapes, but even within those limits there is room for a large number of products.

Special Techniques

Multi-colored extrusions for decorative effects and identification applications are made by two methods. The first process uses several small extruders, standing side by side, to deliver different colored components into a common die. The alternative is a twin-screw extruder which delivers two strips, one above the other, which are brought together while still hot to form a single strip with one color on top and another on the bottom.

Plastic extrusions can be produced in curved shapes by another special technique developed by the Anchor Plastics Co. Conventional tubing, rod and other simple shapes are bent easily enough, but more complex shapes cannot be forced into curved forms without distortion. In the more rigid plastics, curved forms that are bent after extrusion may also tend to revert to rectilinear shape by the phenomenon known as plastic memory. Anchor's technique gets around these difficulties by producing a continuously curved piece which can be cut to size and fitted to circular, elliptical or other desired curvatures. The ends of a patented mounting ring and sleeve assembly produced by this method for metal television tubes come together in a lap joint, and the pressure of a rubber band in a groove in the ring is sufficient to maintain its shape.

Thin sheets of polystyrene are extruded and oriented in different directions in a composite sheet by the Plax Corp. This process makes the material flexible and tough without impairing its electrical and chemical properties. Applications of Polyflex, as the material is called, include strips formed for use in storage battery assemblies, spiral wound tubing for electrical insulation purposes, and washers stamped and punched for high frequency electronic insulation.

Average Commercial Tolerances on Extruded Plastic Parts

Range of Dimensions (in In.)	Thickness			
	Under 1/32	1/32 to 1/16	1/16 to 3/32	3/32 to 1/8
Width				
¼ and under	±0.005	±0.005	±0.005	±0.006
¼ to ½	±0.007	±0.008	±0.008	±0.009
½ to ¾	±0.008	±0.009	±0.009	±0.010
¾ to 1¼	±0.015	±0.015	±0.018	±0.020
1¼ to 2	±0.015	±0.020	±0.020	±0.020
2 to 3	±0.020	±0.020	±0.025	±0.025
3 to 5	±0.025	±0.025	±0.032	±0.032
5 to 10	±0.045	±0.050	±0.055	±0.060
10 and over	±0.060	±0.080	±0.090	±0.125

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"Extruded Metal Shapes and Their Uses", by T. C. DuMond, MATERIALS & METHODS, Aug. 1950, pp. 65-76.

"Film", by M. R. Gerow, in A MANUAL OF PLASTICS AND RESINS, IN ENCYCLOPEDIA FORM. Chemical Publishing Co., Brooklyn, N. Y., 1950.

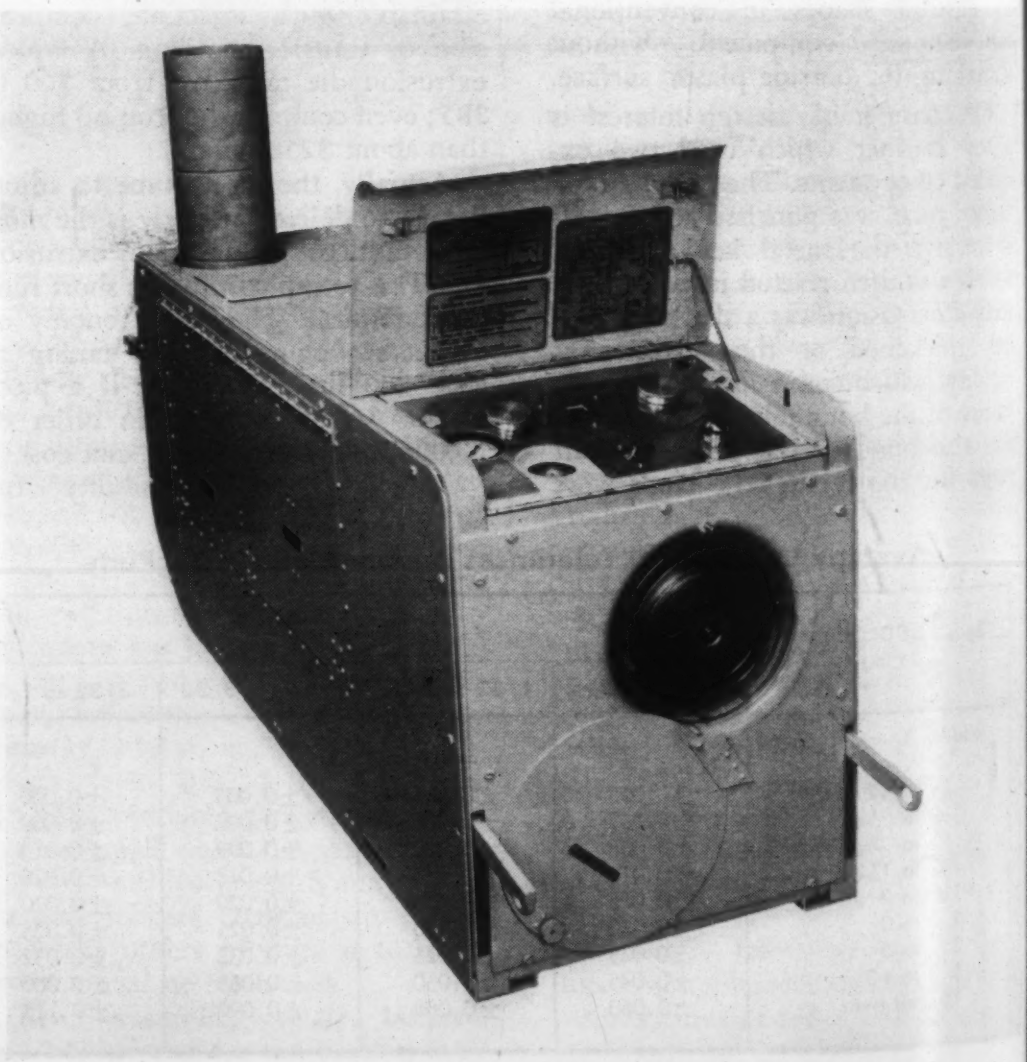
Saving Weight with Magnesium Housings

by R. G. GILLESPIE, Brooks & Perkins, Inc.

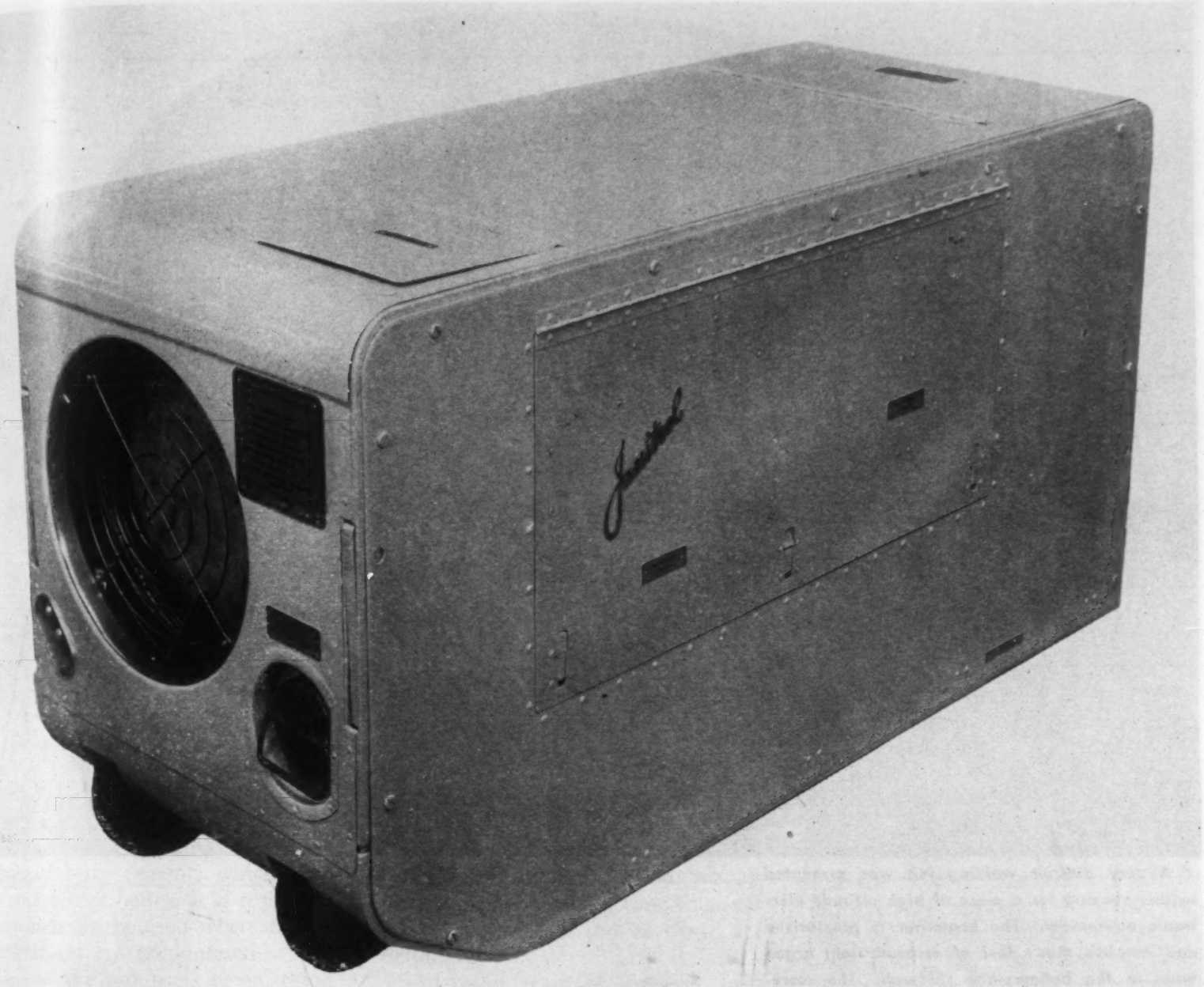
In applications where weight saving is worth the additional expense, magnesium can sometimes replace steel and aluminum in housing assemblies without loss of necessary strength.

● THE WEIGHT-SAVING possibilities of magnesium have been utilized in many types of industrial products. In transportation any lowering of dead weight may increase the pay load or cut fuel costs. Many kinds of portable items can increase their saleability or save labor costs by reducing weight. In the case of military items, the present emphasis on air transport makes it necessary to consider weight and the possibilities of reducing it in many items in which weight has never been an important consideration.

Weight saving is most important in connection with the larger assemblies, because the greatest possibilities for savings occur there. While the large units are of such diverse nature that any general substitution would be impossible, the housings for such units are often suitable subjects for examination as to weight-saving substitution. In these housings magnesium can frequently replace steel or aluminum with a considerable saving in weight, and without loss in necessary strength, since the housing is seldom a part of the working structure. Where the saving in weight is important enough to offset the higher cost, magnesium can pay its way. This may involve the forming of magnesium sheet by deep drawing, the use of welding and mechanical fasteners for assembly, and the forming of framing members. In each of these examples, the housing was originally designed for aluminum fabrication, before magnesium was used to replace it, gage for gage, and give a weight saving of two-thirds in each case.

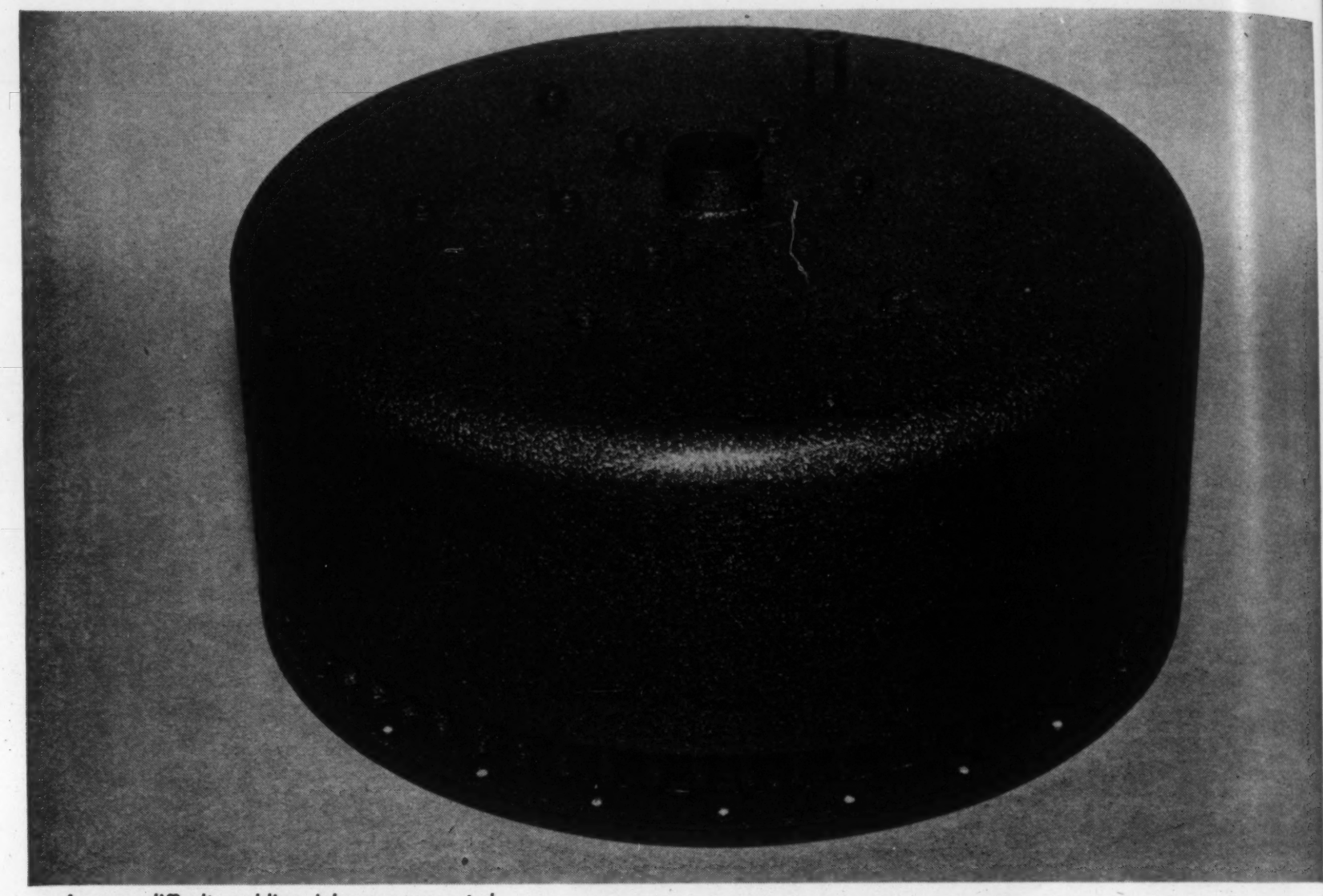


Typical of the use of magnesium housings is this ground heater for aircraft. The mechanism of the heater consists of a spark-fired oil burner with stainless steel heat exchanger chambers, an Inconel radiant tube and a forced draft air system. Magnesium alloy FS is used for the sheet and extruded angle stock, with extruded magnesium channels for stiffeners and latches made by cutting pieces from another extruded magnesium strip. The frame is made by bending the two 1 1/2- by 1 1/2- by 1/8-in. angle side members to shape. This frame is notched at the bend points, coated with graphite, torch heated to about 500 F to prevent cracking, and formed on a standard bender. The bottom panel is made of corrugated magnesium sheet 0.064 in. thick. To this sheet, two extruded 1- by 3- by 1-in. channels, 1/8 in. thick, are welded by argon shielded arc welding. These channels serve as runners on ice or snow when the built-in wheels are not serviceable. The panels are assembled to the frame by riveting and bolting, with one side, one end and the top bolted for easy access. The permanently assembled sheets are made of 0.064-in. stock, and the removable panels are cut from 0.091-in. sheet stock.

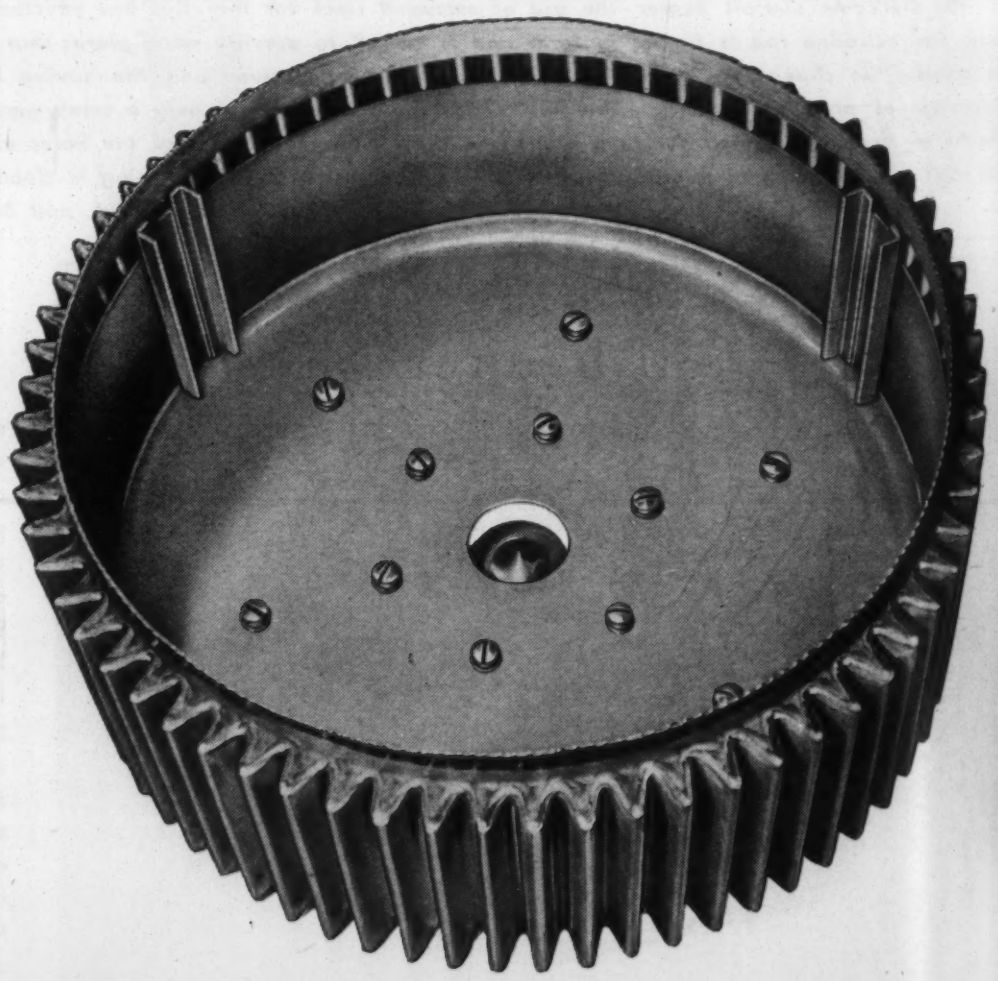


On the same aircraft heater, the use of extruded stock for the clips has effected a saving over forming the clips from magnesium strip. The extruded rod is simple in form and is cut off to provide small pieces that require no additional processing other than drilling to complete the clips. The favorable price on extruded magnesium and the saving in forming costs give the extruded clips a price advantage of about $.20 each. The two end panels also require only a small amount of fabricating before assembly. Circular holes for the air vents are routed out to a diameter of 10½ in., the edges of the holes are heated to about 550 F by gas heater jets and the holes are flanged and punched for two bolts. After assembly, the housing is cleaned in hot caustic, pickled in chromic acid, treated in the standard Dow. No. 7 baths, rinsed, and finally painted.

This housing for a teletypewriter is another example of weight saving in a product without changing the design or the materials used in the actual working mechanisms. The housing is made up of a magnesium base and cover. The base is a single flat sheet, 0.081 in. thick, cut to the required outline in a blanking operation, with rigidity provided by a rolled edge and formed stiffening ribs. Holes are drilled in the base for attaching spring clips and for the electrical connections to the teletypewriter itself. The clips are riveted on. The cover is drawn in one piece from FS magnesium alloy, 0.064 in. thick, with a draw about 14 in. deep. Dies are heated to about 550 F, and the draw is made in one operation. The piece is then rough trimmed, the rear window cut through by a hand router, and the holes for the fasteners are drilled. The piece is finish trimmed in the router fixture.



A very difficult welding job was presented in this housing for a piece of high altitude electronic equipment. The container is pressurized and requires many feet of pressure-tight argon weld in the bellows-like sidewall. The corrugated sidewall is made of 0.064-in. sheet, welded top and bottom to 0.091-in. material. At the bottom of the unit is a main ring of 1/2-in. magnesium welded to the lighter stock. All these parts are of FS magnesium alloy. An outer shell of the same material, which fits over the corrugated inner container, is made by welding a spun disk to the rolled side cylinder. The most exacting operation in the manufacture of this container is the welding of the corrugated side walls and other pressure-tight joints. The welds are made with 3/32-in. wire of C alloy, using high frequency alternating current. The argon gas gives good shielding and cuts down porosity in the welds. Another interesting feature of the design was the change in the three guide rails mounted on the inside of the container running the full depth of the unit. These guides position the mechanism inside the housing. When the units were first being manufactured the rails were made by forming sheet magnesium into a channel, and riveting an angle along each side of the channel. The rivets were countersunk inside and out to give good sliding surfaces. By redesigning the guide rails as a double-chanelled extrusion that required only cutting to length, a saving in the cost of the material of nearly one-third was accomplished and fabricating time was reduced from more than 30 min. to 0.3 min.



Improved Corrosion Resistant Cements Have Many New Applications

by C. R. SIMMONS, Durez Plastics & Chemicals, Inc.

• THE USE OF synthetic resins in corrosion resistant mortars or cements is not new. In fact, for the past 20 years a phenolic-type resin has been the most generally used bonding ingredient in such cements. The physical properties and characteristics of the phenolic resins have made these cements outstanding. Nevertheless, their use has been somewhat restricted because they are primarily acid-proof and not alkali-proof.

Today, corrosion resistant cements are finding far wider use than ever. The reason for this is directly traceable to the development of furfuryl-alcohol resins for use in this application. These are making it possible to manufacture cements which have as good, if not better, acid resistance and which can be used where higher temperatures are encountered.

One of the producers of corrosion resistant cements, Electro Chemical Supply & Engineering Co., has developed a cement called Lecite. This is an acid- and alkali-proof material consisting of two basic parts—a liquid binder containing a Durez resin, and a powder containing filler and the chemical setting agent. Lecite is said to be inert in all acids, organic and inorganic, with the exception of a few strongly oxidizing chemicals, inert in most organic solvents and all alkalis of any concentration.

Applying corrosion resistant cement in the construction of an acid tank.

It will withstand temperatures up to 370 F, and is so dense that salts cannot penetrate and crystallize within a joint. It has a tensile strength of 1000 psi and a compressive strength of 10,000 psi. Lecite sets quickly by chemical action yet allows sufficient working time to avoid waste. Unmixed, it can be stored indefinitely.

Corrosion resistant cements such as this are required in plants producing textiles, steel, phenol, paper, soft drinks, dairy products, food products, alcohol, nylon, soap, copper sulfate, acids, organic chemicals, and many other products. They are used in these plants, for example, in brick-lined pickling tanks, storage tanks, fume stacks, absorption towers, manholes, and waste-neutralization tanks. In one plant, for instance, a brick-lined reactor is handling a mixture of hydrochloric acid and organic solvents at an operating temperature of 350 F and a working pressure of 40 psi. In another, dilute sulfuric acid at 70-lb steam pressure is passed through a digester.

In the construction of acid- or alkali-proof equipment, special consideration must be given to a number of factors, including the design of outlets, covers and supports; the method of heating; and the type of supporting shell. The two most commonly used exteriors are of welded steel or reinforced concrete. Either must be tested liquid tight and function as a rigid support for the acid-proof brick lining.

Tanks and similar equipment of reinforced concrete or steel must be lined with an impervious membrane before installing the acid-proof brick lining. This membrane can consist of rubber, synthetic rubber, vinyl-type resins, asphalt-resin compositions, glass cloth reinforced infusible resins, and lead. The final selection depends upon the chemicals to be handled, maximum temperature during operation, and the type of supporting shell used.

Primarily, the acid-proof brick lining provides thermal and mechanical protection for the impervious membrane. Its thickness is determined by the dimensions and shape of the unit, the temperature of the solution, and the type of membrane used. It is extremely important to select the correct acid-proof cement to join the brick lining, and the following factors govern its selection: (1) chemicals involved in the process and their concentrations; (2) the maximum temperature of the solution or gas; (3) thermal shock; and (4) abrasion.

In those plants where an acid-proof brick or tile floor is desired, the new corrosion resistant cements also have an important role. In this type of construction, an impervious membrane is used between the concrete sub-base and the acid-proof brick or tile. It has proved to have excellent wear resisting properties and will withstand severe traffic.

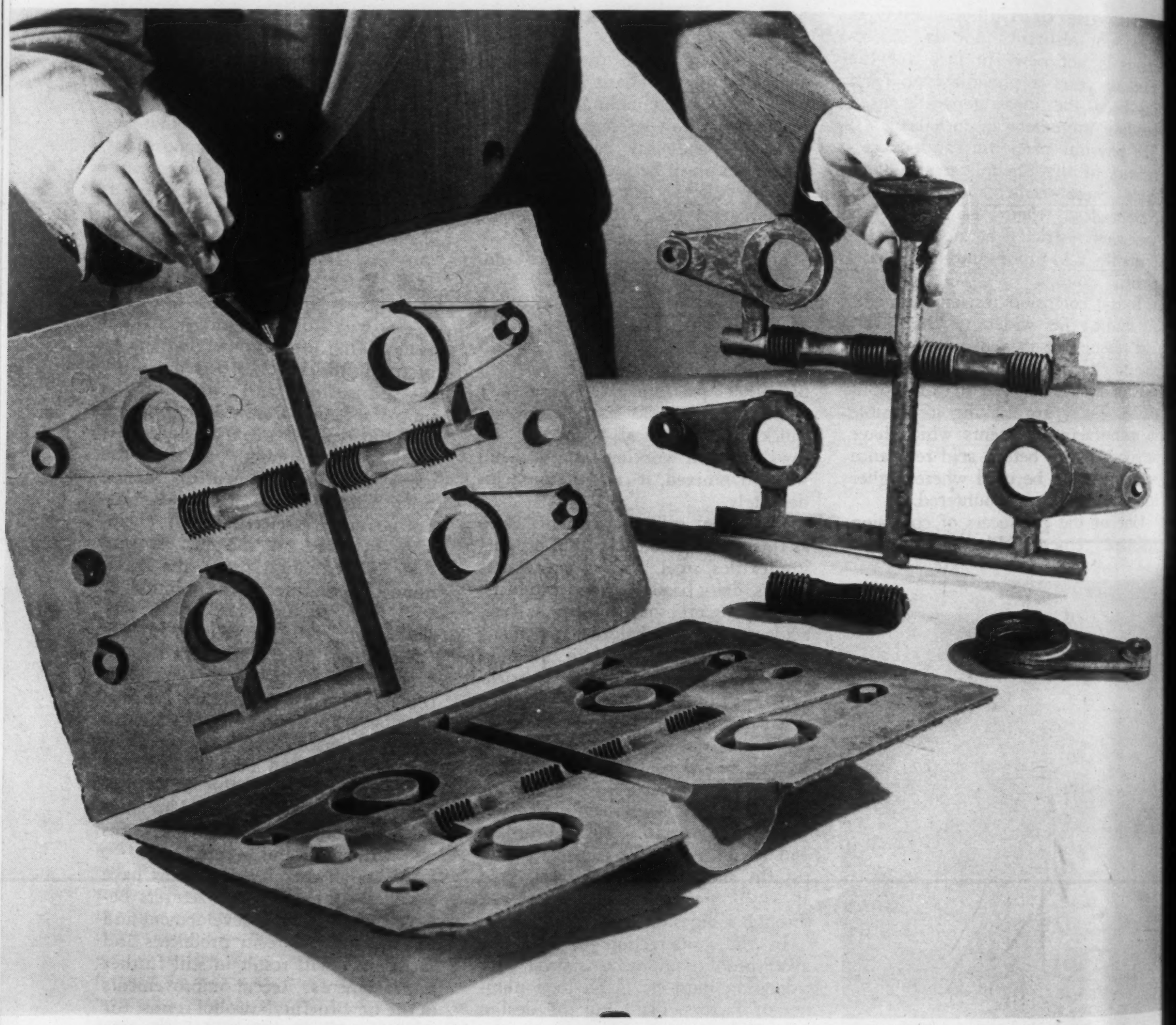
Although these cements now have a widespread use, manufacturers believe that continued development and research by the resin producers and themselves will result in still further improvements. Recent improvements in the new furfuryl-alcohol resins, for example, give promise of cements with greater impact strength, better shrinkage properties, and improved ability to adhere to ceramics, concrete, metals, glass cloth and rubber. Such developments, it is felt, will broaden the scope of the new cements even more.

Materials at Work

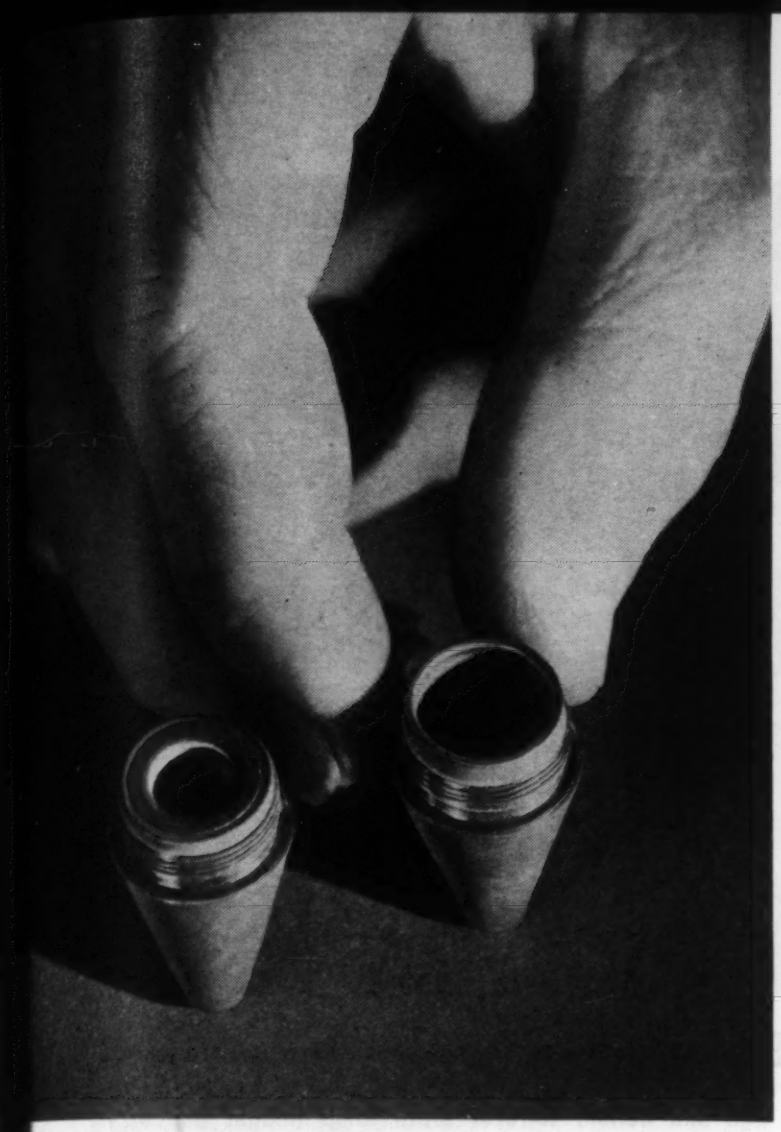
Here is materials engineering in action . . .

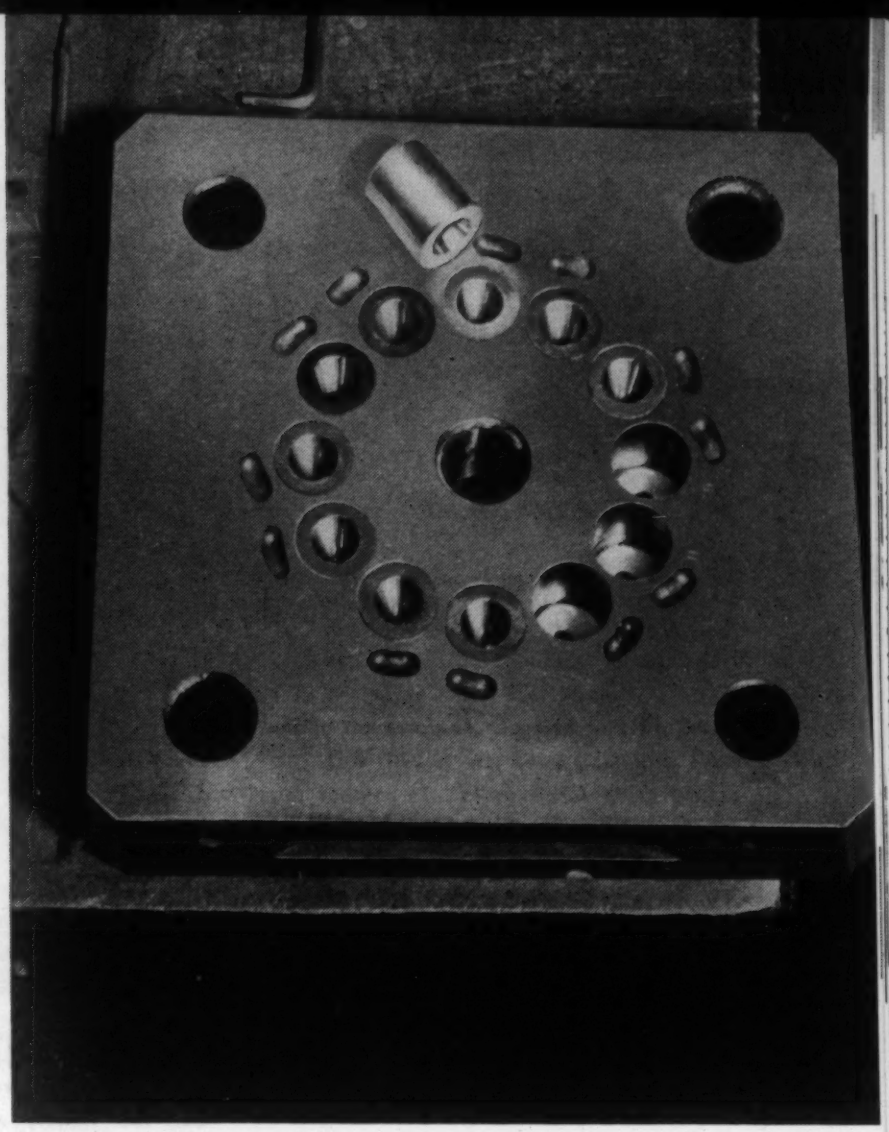
New materials in their intended uses . . .

Older, basic materials in new applications . . .

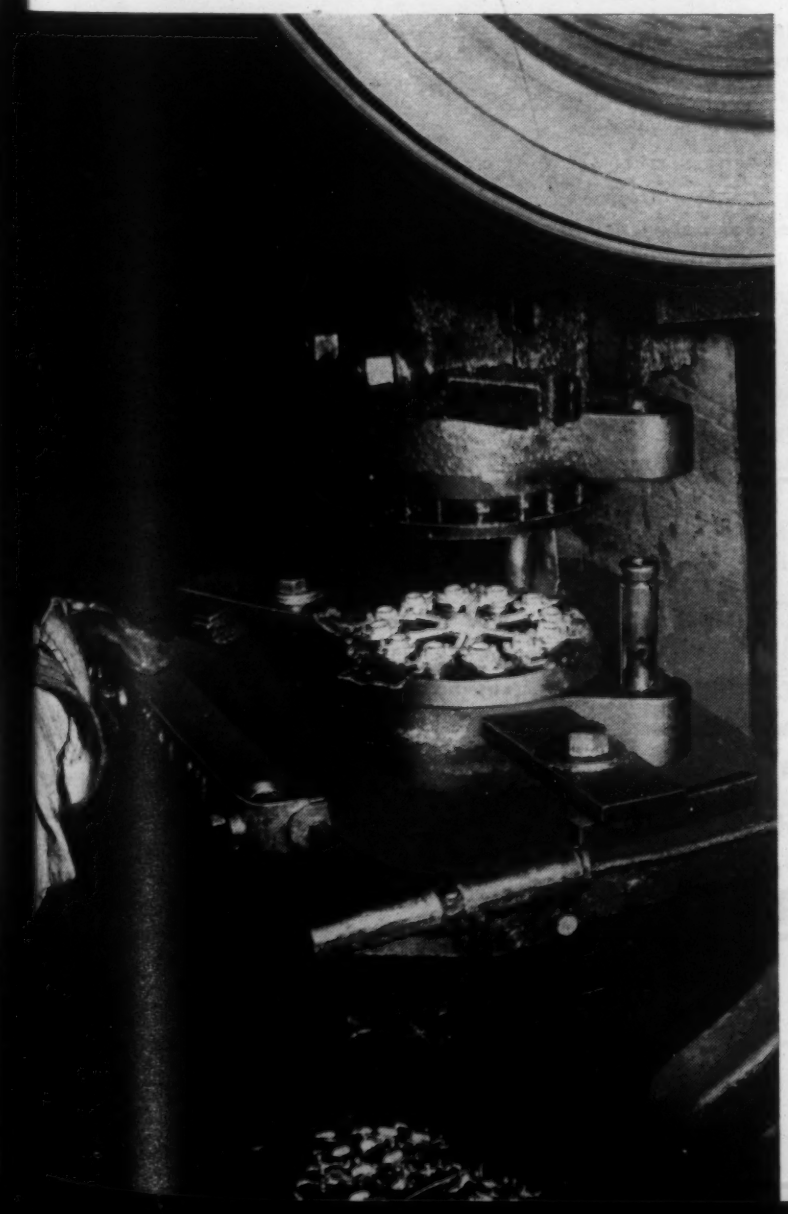


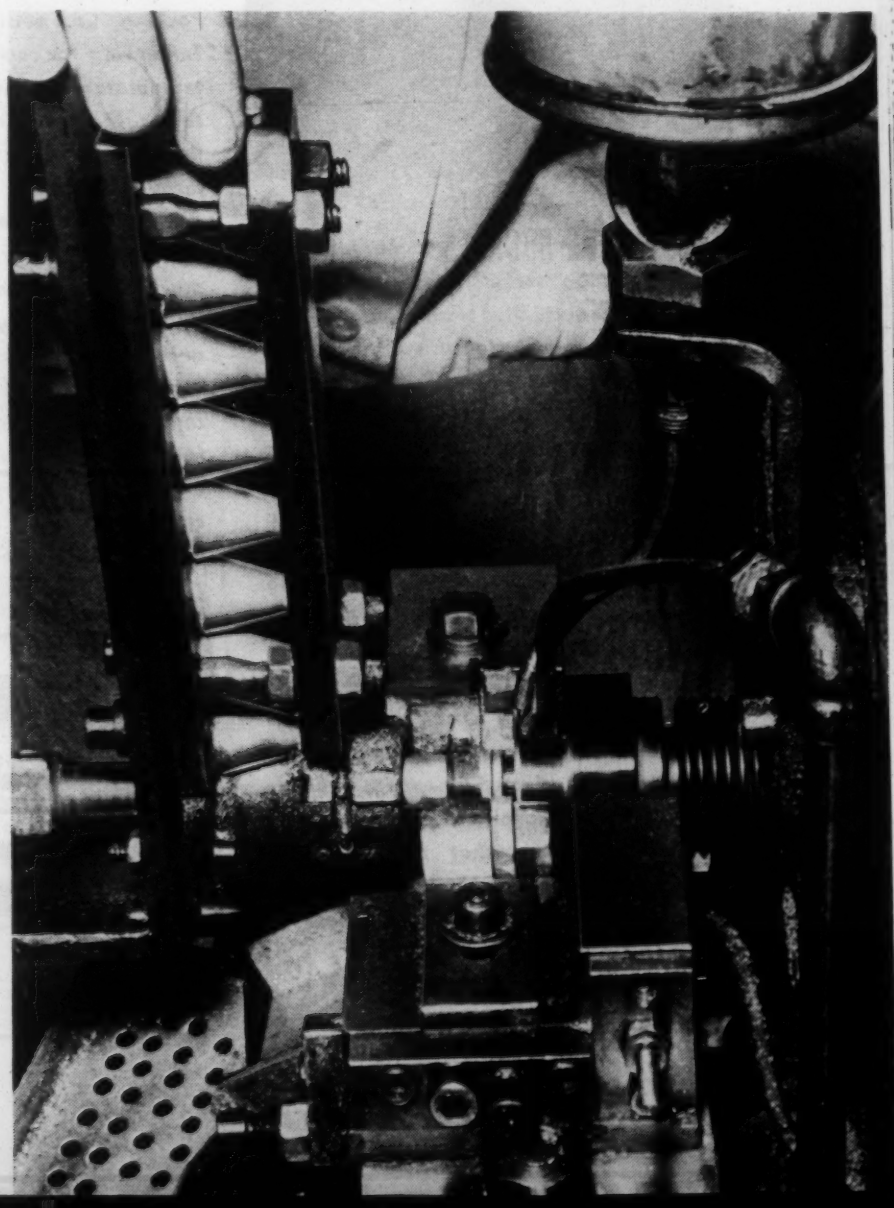
PHENOLIC BONDING RESINS *The patented Croning Process of Crown Casting Associates employs thin-shell, single use sand molds bonded with Bakelite phenolic resins. The mixture of sand and resin is applied in a thin coating to the surface of a heated metal pattern, then baked hard to form half a mold. Clamped together, the two halves of a mold are placed in a flask, surrounded by metal shot or similar bedding material, and the metal is cast. The process conserves metal because pieces can be held to tolerances reported as 0.002 to 0.003 in. per in., reducing scrap waste and machining. Space is also saved, since the molds can be stored instead of the castings. In addition, the process cuts down on the handling of sand since shell molds require only 10% of the sand required for conventional molds.*

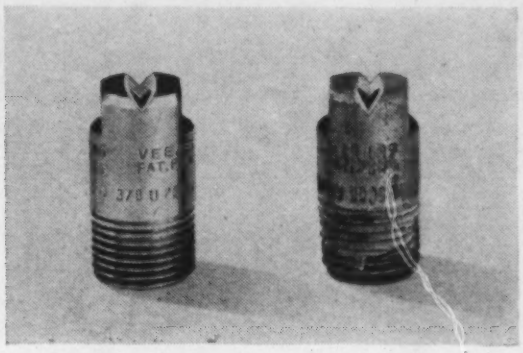




ZINC DIE CAST FUSE NOSES *Typical of the zinc die cast ordnance components now in production are the M99 and M96 fuse noses made by the Rupert Die Casting Co. of Kansas City. A 12-cavity die, with the individual cavities made in cylindrical steel inserts in the die block, is used for both items. Since the noses are cast in zinc alloy, high-speed plunger-type casting machines can be used to give an hourly production rate of 2700 fuse noses per machine. The gate of 12 castings is freed from the die automatically by ejector pins bearing on the metal runners between the noses, and the gate is then quenched to prevent distortion in handling. Every hour each of the 12 castings of a test gate are checked for dimensional tolerances. A punch press, shown below, clears the castings from the gate, pushing them through trim dies into a tote box below. The fuse noses are then machined on an automatic-feed lathe which undercuts, grooves and threads the shoulder of each casting. A final visual inspection is made before shipment.*

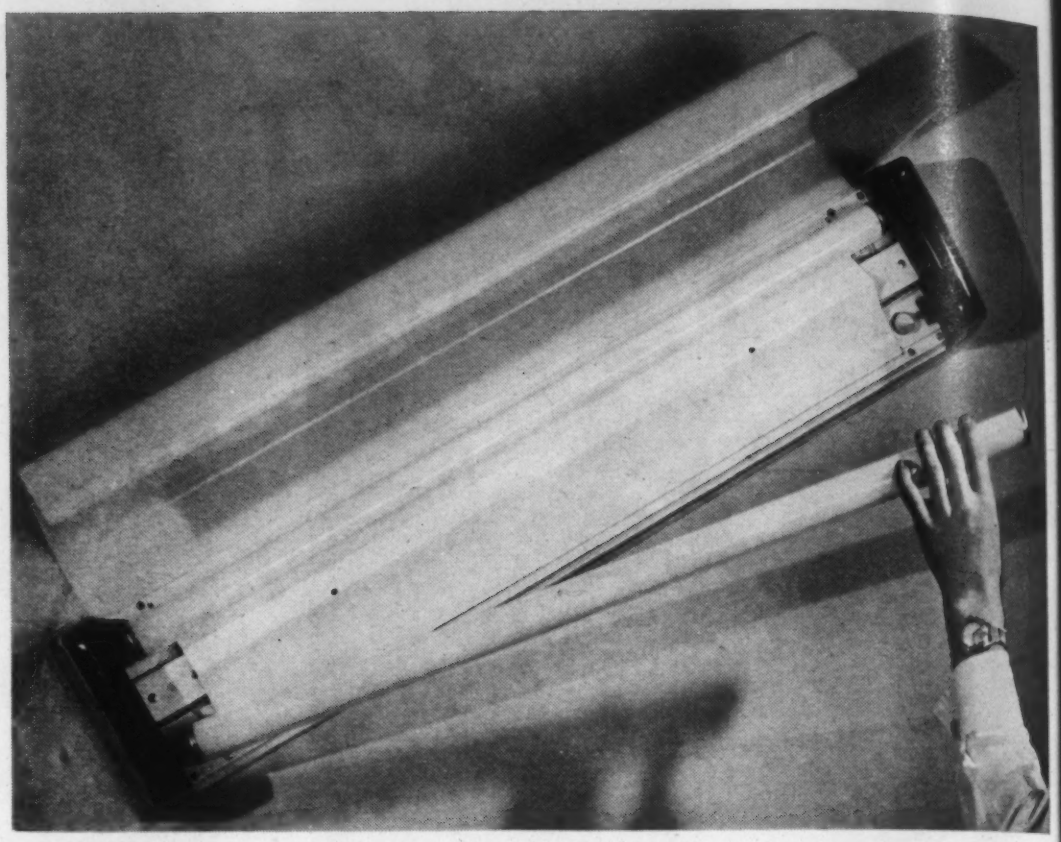






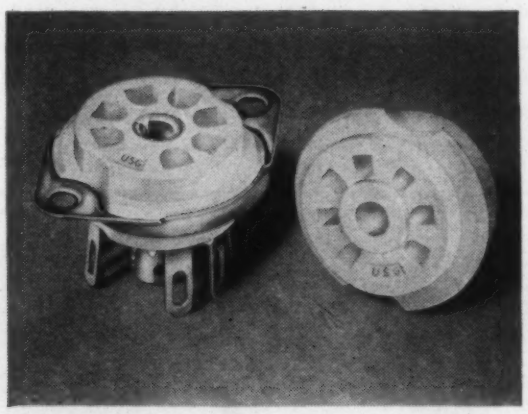
STAINLESS SULFURIC ACID JETS

Vee jets used by the R. C. Mahon Co. were badly corroded in a short time by the 8% sulfuric acid used at 160 F in a metal pickling process. Replacement of the 18:8 stainless steel jets (right) was necessary every two months. To combat this problem, Carpenter Steel Co. No. 20 Stainless Steel (left) was substituted, and the jet life was increased by more than six times. This relatively new steel is a low carbon alloy with 1.00 silicon, 2.00 (min) molybdenum, 3.00 (min) copper, 20.00 chromium and 29.00% nickel.



EXTRUDED LIGHT SHIELD

This fluorescent light fixture features a clear white diffusion shield extruded from Bakelite styrene plastic. The shield is made by the Plastic Process Co., Inc. Finely ribbed side and bottom surfaces erase lamp images and diffuse light uniformly over the surface. The excellent light reflectivity of styrene plastic provides maximum light transmission, and the plastic surface will not drip, crack or discolor. Another interesting feature of the shield is its destaticizing finish, which acts to repel dust and minimize cleaning. The new fixtures are also relatively easy to unclamp; the ends can be slid out to allow the one-piece shield to swing open on hinges. Relamping involves no unscrewing or unbolting.

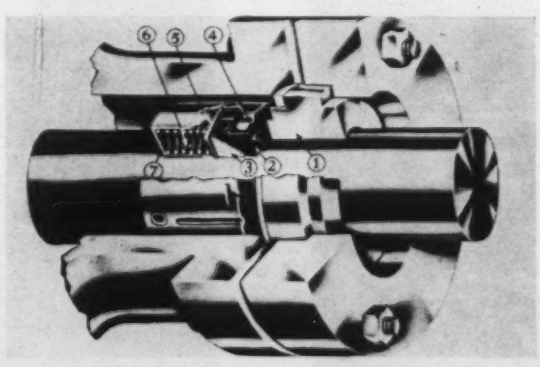


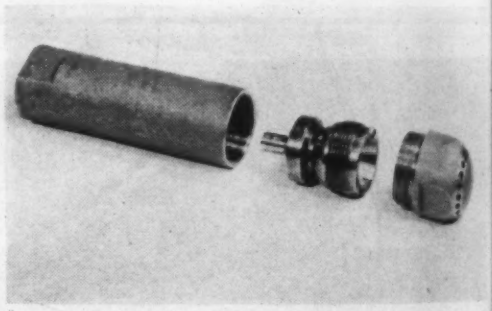
TEFLON TUBE SOCKETS

Miniature 7-pin Teflon tube sockets, manufactured by the Teflon Products Div. of the United States Gasket Co., are designed to meet RMA and JAN electronic specifications where high or low ambient temperatures or frequency stability are problems. The loss factor of Teflon is less than 0.0005 and its dielectric constant is 2.0 from 60 cycles to 30,000 megacycles. The material is serviceable from —110 to 575 F for long periods with negligible change in dielectric strength and power factor, and unlike other plastics, will not carbonize in case of arcing. The ASTM water absorption rating is 0.0%, and the physical and electrical properties cannot be affected by extreme humidities, corrosive atmospheres or fungus. Teflon is tough, somewhat resilient, nonflammable, and chemically inert to oil and all organic acids, solvents and alkalies.

TEFLON FLEXIBLE SEAL

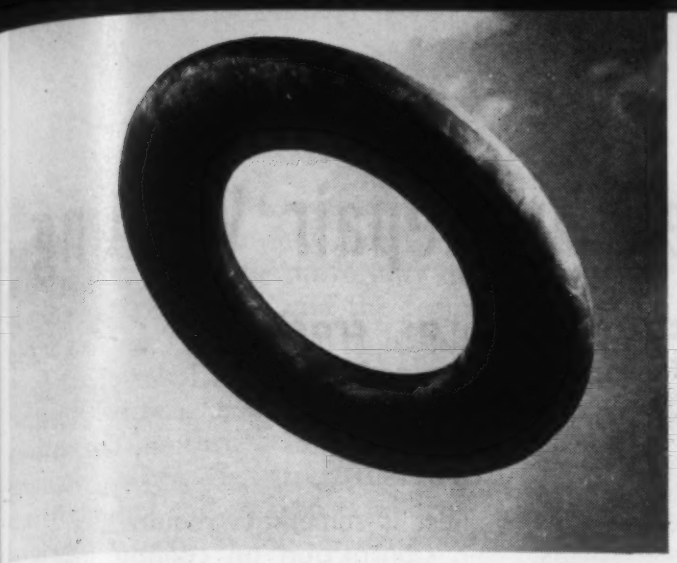
Rather than leather or synthetic rubber used in most flexible mechanical seals, the Type 9 Crane Packing Co. seal incorporates a flexible Teflon ring for corrosive services up to 500 F temperatures. The set-screwed metal retainer (7) provides a positive drive from the shaft to the carbon sealing washer (2) through dents (4) which fit into notches in the washer. An effective seal between the shaft and the washer is ensured by the machined Teflon wedge ring (3), preloaded by multiple springs (6). Spring pressure is uniformly distributed by a metal disk (5). The lapped raised face of the rotating sealing washer (2) runs against the lapped face of the stationary seat (1) to provide a seal. Spring pressure keeps the faces in constant contact, providing automatic adjustment for wear and shaft end play.





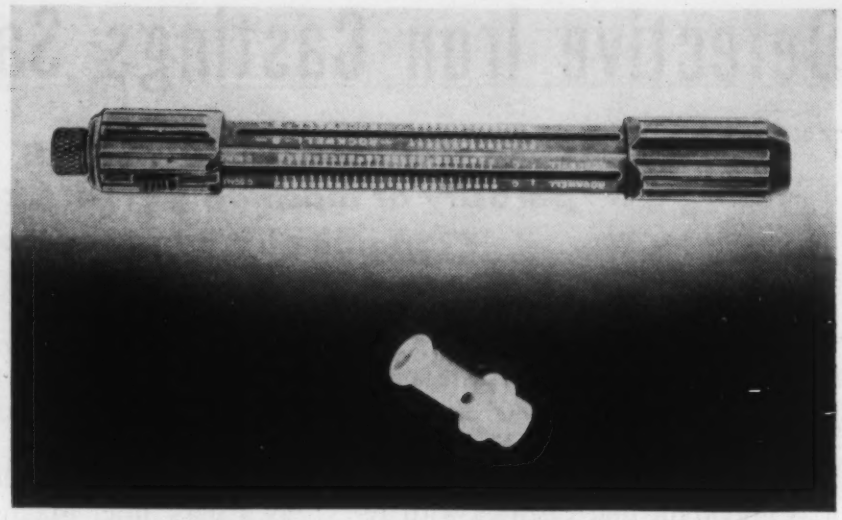
INVESTMENT CAST ATOMIZER

This monel atomizer was designed by the Engineer Co. to break sludgy and low grade fuels up into a fine mist for furnace combustion. The design was intricate and critical and the original machining costs high: five separate parts were needed; 38 holes were drilled at precise angles; four sets of threads were cut; an odd conical shape was to be machined within the tip. Yet the design could not be changed without sacrificing efficiency. When investment casting was considered, it was found that the number of parts could be cut to three, and although some finish machining would still be required, machining costs were lowered enough to effect a 25% reduction in the overall manufacturing costs, as compared to the original, all-machined design.



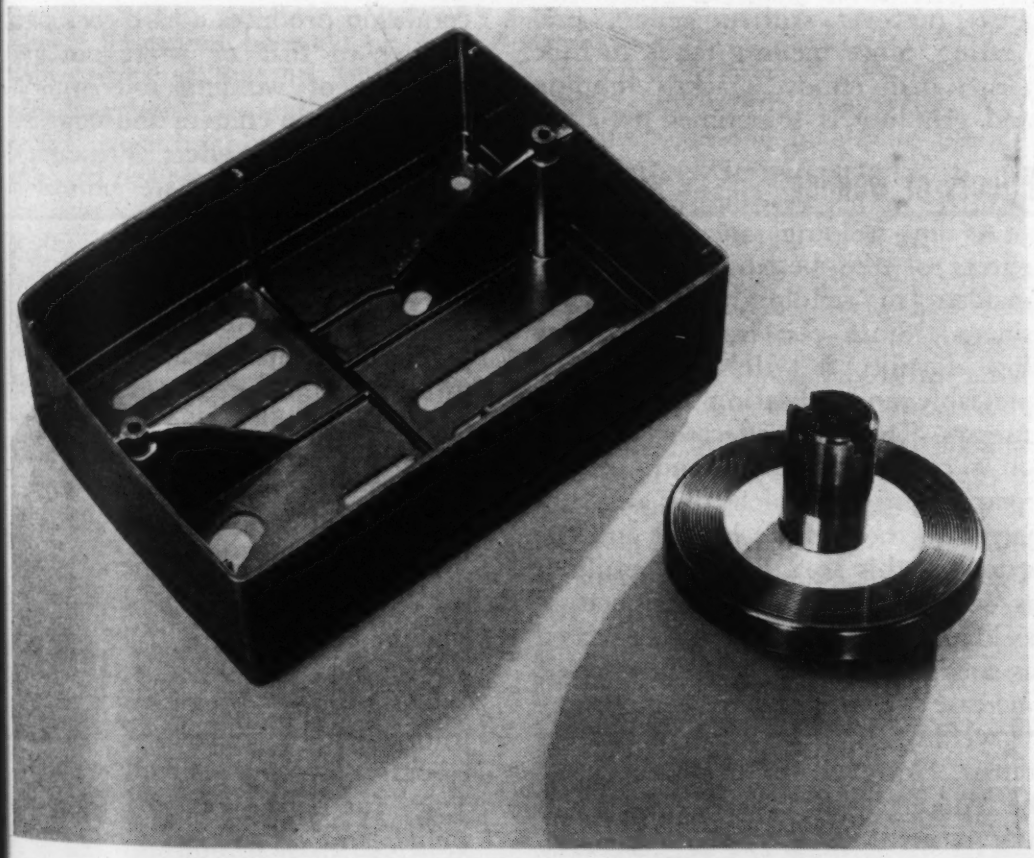
EXPANDED PLASTIC LIFE RING

A new plastic, known as Expanded Royalite, for use in life rafts, life ring buoys and other flotation equipment, is honeycombed with tiny nonconnecting cells which make it extremely light and at the same time immune to strafing or damage in the water. Life ring buoys of the new material are fire resistant, unaffected by sun or salt water, and lighter, stronger and easier to handle than the conventional type. Expanded Royalite is also an excellent thermal insulator; because the material absorbs little or no moisture, its insulating properties remain good for years. Exposure to water and weather, by the same token, have no deleterious effects on its unusual dielectric properties. Flat sheets of Expanded Royalite, varying from 5 to 35 lb per cu ft in density, depending on the application, can be formed by conventional thermoplastic forming techniques or molded to shape.



NYLON RETAINER

The Metalometer portable hardness tester, made by Peabody Industries, Inc., contains a hardened steel rod which is locked in position when raised by the knob at the top of the tester. Release of the trigger just above the hammer releases the plunger, which rebounds from the surface of the metal being tested. At the highest point of the rebound, the plunger is locked in position to permit hardness readings on Rockwell C, Rockwell B and Brinell scales. Locking the plunger is accomplished by three steel balls in a retainer machined from FM-10001 nylon rod. The principal reason for using nylon is the material's excellent anti-friction qualities which prevent instrument inaccuracies. Nylon does not require lubrication and is not affected by shop cleaning fluids.



PHENOLIC RECORD TURNTABLE

The new record player turntable molded by the General Die Mold Co. for RCA from a special Durex phenolic material costs one-half and weighs one-third as much as the former die cast metal part. The engineering requirements for the turntable were very strict: a thermosetting material was required because dimensional stability was primary; the metal insert had to be anchored securely because the motor stress in starting is all on the spindle; no change can be tolerated in the contour of the flat surface since concentricity and avoidance of vertical wobble are important. One slight design change, thickening the flat section under the brass ring, was suggested by the molder to ensure holding adequate material in the post section. Another design change in the phenolic housing involved the addition of reinforcing ribs to the mounting bases to guard against misalignment. In plastic, these ribs could be added by a slight change in the mold design.

Defective Iron Castings Saved by Repair Welding*

Cast iron parts, containing such defects as cracks, porosity or machining errors, can frequently be salvaged economically by proper use of repair welding.

• DEFECTIVE CAST IRON parts can be saved from the scrap pile more often than is generally realized by proper use of repair welding. In this period of critical material shortages it is important that castings with repairable defects be salvaged wherever it can be done economically.

One of the main problems in the repair welding of cast iron is to know when welding can be accomplished effectively and economically. To a large extent, this can be determined from the size of the defect and whether or not a technique can be established that does not impair the machinability or serviceability of the casting.

Of primary importance in deciding whether or not to repair weld is the amount of welding that will be required. This will determine the choice between welding and recasting from an economic standpoint, and, where welding is decided upon, which method to use. Other criteria are the location of the flaw, the amount of machining already completed, and the equipment and skill available in the shop.

The defects in cast iron which can usually be repair welded are misruns, cold shuts, laps, blowholes, cracks, and porosity. In addition, broken off portions, mis-machined dimensions, tool gouges, etc., are repairable within limitations. In the final analysis, however, the extent to which defects can be repaired by welding must be determined by trial and error, and the experience so obtained used as the ultimate factor in deciding whether or not to weld.

Defects are generally located by visual inspection of rough castings after sand blasting, and should be clearly marked before sending the casting to be repair welded. If it is found that visual inspection does not indicate all defects, there are several other, more sensitive, methods. Some of these entail testing the casting with water for leaks, soaking the suspected area with kerosene or mineral spirits, then wiping it dry and coating it with chalk. The liquid in any crack will flow out, wet the chalk, and show up as a dark line. Magnetic particle inspection, acid etching and radiography are of value for occasional quality control. These inspection techniques, together with metallurgical examination, are also used for proving new procedures.

When the defects have been located and indicated, they must then be completely exposed and the adjacent area thoroughly cleaned of sand, oil, water and other foreign matter, prior to welding. Melting out defects by means of a torch is most commonly employed when gas welding is to follow immediately. Melting should not be used on restrained areas, however, without general preheating. Since melting tends to hide rather than remove cracks, chipping and grinding is sometimes used.

Effects of Welding

As in welding any metal, the effects of the heating and cooling incident to welding must be considered. Since cast iron has a very low ductility it will not yield appreciably under heating and cooling stresses. The exact effect of welding on a cast iron part depends on the temperature to which the area adjacent to the weld is heated and the extent of this area. For best results it is desirable to keep the temperature as low as possible and the area heated as small as possible. Of course, some increase in temperature is necessary if welding is to be used to effect a repair. However, the heated area can be reduced by the choice of arc welding rather than gas welding. Nonferrous electrodes are of still further aid.

Since it is the difference in temperature between the weld area and the surrounding cold area which causes variable expansion, hence cracking, another solution is to preheat the part and thereby also expand the adjacent base metal. Local preheat may suffice, but general preheat is sometimes required.

Contraction on cooling may also induce cracks. A molten weld deposit undergoes considerable contraction when solidifying and cooling to room temperature. Rupture of the metal may result immediately or may occur after the part is put into service. Slow cooling, or stress relief followed by slow cooling, is necessary to prevent this possibility.

Nickel and nickel alloy electrodes are also effective in minimizing cracks resulting from shrinkage stresses since these materials stretch considerably. Peening may also be helpful.

Hardness in and adjacent to welds is affected by the rate of cooling from the welding temperature. Rapid cooling causes some of the carbon to remain combined with the iron. This condition produces a hard constituent similar to that of white cast iron. The use of welding rods with increased silicon content and slow cooling reduce this effect. Preheat and postheat treatments are utilized to delay the cooling rate.

Higher strength cast irons may lose their strength as a result of excessive preheat or stress-relief temperatures. A maximum safe temperature should be determined prior to establishing a specific welding procedure.

Preheat and Stress Relief

General Preheat—General preheat is required when a considerable amount of welding is to be done on a restrained portion of a casting.

The purpose of preheating is twofold. First, it reduces the rate of cooling, thereby lessening the tendency for hard spots to form at the welds, and second, it minimizes localized expansion and contraction which induce cracking. Frequently it is more satisfactory and more economical to preheat entire castings. However, since a general preheat results in some movement and consequent loss of dimensions, its use is limited to unmachined or partially machined castings.

The rate at which a given casting

*** This article is adapted from "Recommended Practices for Salvaging Automotive Gray Iron Castings by Welding", as prepared by the Automotive Welding Committee of the American Welding Society.**

can be brought to preheat temperature and allowed to cool therefrom is dependent upon the uniformity of heating in the furnace and the form of the casting. Castings can be heated more uniformly by a continuous preheating furnace. Such furnaces are constructed so that castings can be preheated when fed from the cold end to the hot end and stress relieved by moving them in the opposite direction in the same furnace.

A preheat temperature between 1000 and 1050 F is recommended for ordinary gray iron parts. The limiting maximum temperature on any particular grade of cast iron is the temperature at which it begins to lose strength or hardness. This temperature should be determined for the iron used and a safety factor of at least 50 F deducted therefrom.

Local Preheat—Local preheating involves heating a casting only in the area to be repair welded. A welding torch or a gas burner is used for this purpose.

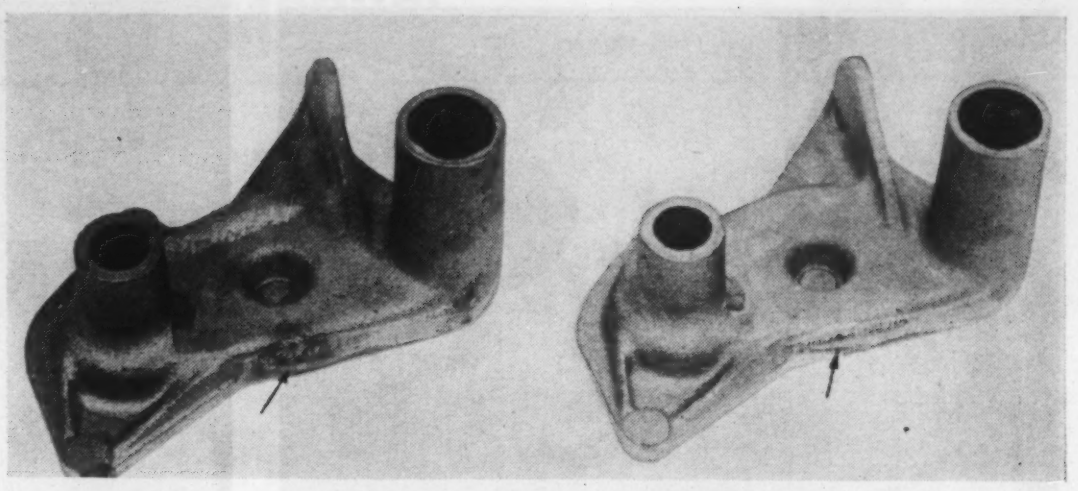
Local preheat is most commonly employed on partially or completely machined castings where general preheat cannot be used due to the danger of dimensional changes through warpage. It cannot be used on portions of castings that are restrained from expansion. Generally, its use is limited to such things as corners, edges and bosses. A skillful and conscientious welder is needed to avoid overheating and misapplication of the heat to restrained areas.

After completing a weld, the flame should be held on the casting for a sufficient time to prevent local hardening. Too rapid cooling after the flame is removed should be avoided.

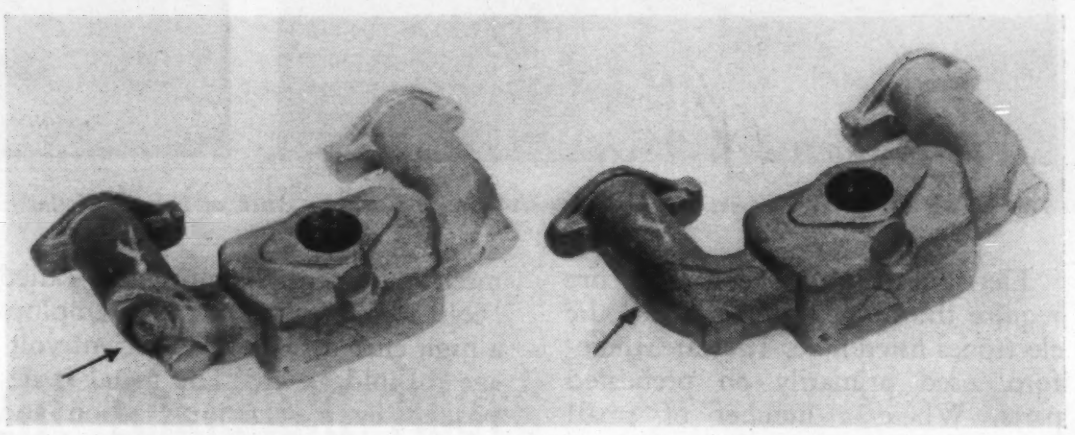
High hardness in arc-welded repairs can be diminished by local preheating. A temperature range of 300 to 400 F is of some value, but at least 1000 F preheat is desirable if the heat-affected zone is to be machined by high-production machine tools.

Stress Relief—Adequate preheat tends to minimize stresses, but too rapid cooling after welding can also produce stresses. In order to overcome this difficulty, it is necessary to subject some castings to a stress-relief heat treatment.

Stress relief must begin before a casting has cooled too far from the minimum welding temperature and, in any case, not below 750 F. Cooling during welding can be delayed by the use of a flexible asbestos shield. This not only stops drafts but also keeps radiant heat from the welder.



Automotive water pump housing with a slag or dirt hole (left), repaired by arc welding (right).



This casting containing dirt or slag in the wall as shown (left) was cleaned and then repaired by oxyacetylene welding.

The maximum stress relief temperature, like the maximum preheat temperature, is also limited to a high point which will not soften castings. For ordinary gray iron a safe range is 1000 to 1050 F. For other grades the range should be determined from the analysis or by experimentation.

The general practice is to allow castings to remain at 1050 F long enough to become uniformly heated and then to cool down at least to 500 F in the furnace. The most efficient cooling rate in the furnace should generally be developed for each type and size of casting.

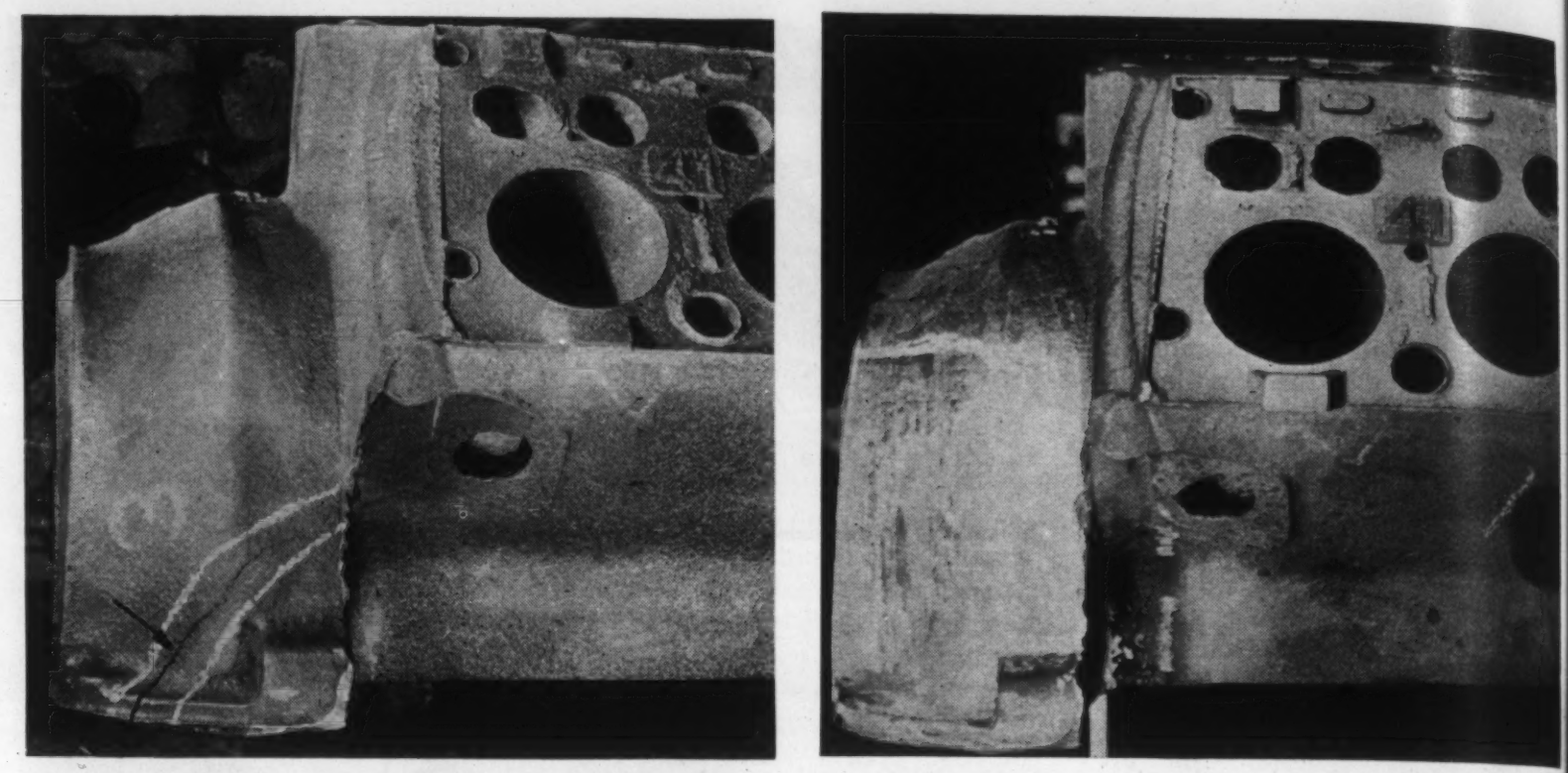
Methods of Repair Welding

The particular method chosen for repair welding is dictated by several factors, among which are the following: (1) condition of casting—rough or machined; (2) location of defect; (3) size and nature of defect; (4) need for color matching.

Oxyacetylene Welding—The most common method in use for the repair of castings is oxyacetylene welding with furnace preheat and postheat. Generally, gas welding is employed on rough castings, particularly in areas where localized heating would tend to produce cracking. In brief, the procedure consists of locating the defect, chipping and grinding, preheating the casting, melting or chipping and grinding out, if necessary, welding, stress relieving, chipping the flux deposit and grinding the weld flush with the casting surface, and reinspecting, in that order. With suitable skill and technique, this method can be used for a considerable amount of repair on a casting.

Where an unrestrained corner or boss is to be repaired, the above method can be modified by using local preheat and postheat. The method is essentially the same as the one above except that only the weld area is heated in both preheat and postheat. Heating should be done by means of a welding torch or a special burner to a temperature of 1000 to 1050 F.

Manual Metal Arc Welding—When a casting has been machined and preheating and stress relief are likely to cause warpage, manual arc welding, with its relatively small heated area, is the only method that can be used except for an occasional corner, boss or flange. The specific procedure to be applied depends upon the type of electrode used.



With proper precautions cracks can be successfully repaired. The crack at lower left (left) was repaired by oxyacetylene welding (right).

Electrodes having a cast iron core require the highest imput of all the electrodes listed here. They are, therefore, used primarily on preheated parts. Where a number of small flaws are to be corrected, manual arc welding with these electrodes is faster than gas welding. Defects must be prepared prior to welding, usually by mechanical means. Where the torch is used for local preheating and melting, it is easier to continue with the torch and gas weld most defects.

Coated electrodes with mild steel cores are used comparatively little, usually to repair small pits and cracks. They have the disadvantage, when deposited, of mixing with some of the cast iron to form a very hard spot which introduces high stresses, increasing the probability of cracking, and which is not machinable without first being annealed.

Heavily coated nickel and monel core electrodes are both used to repair miscellaneous small defects in castings at nearly all locations, including machined surfaces. Beads are deposited in short lengths, peened, and allowed to cool before depositing more. While the deposit itself is easily machinable, the small heat affected zone is difficult to machine and is improved by a 300 F preheat, eliminated by a local postheat of 1000 F. Low-amperage, a.c. or reverse polarity, d.c. is used.

Bare nickel electrodes are used in two similar methods for making small repairs, particularly in bores where the almost complete absence of a heat-affected zone is desired. The first method, sometimes improperly called "cold" or "battery welding", employs a high current without sufficient voltage to hold an arc. The metal is deposited by a scratching action and requires skill to secure a fair bond and a deposit free from flakiness and porosity. Extensive peening is used to obtain sound deposits.

The second method, utilizing bare nickel electrodes, is known as intermittent welding and requires a special transformer which periodically interrupts the current to prevent the generation of high heat. This method is generally preferred over the first because it is faster, gives better bonding, and produces a sounder deposit. Other nonferrous electrodes are used, each permitting the use of slightly different current characteristics.

Braze Welding—Occasionally defects on bosses, corners, edges, etc. are repaired by braze welding. This method, similar to oxyacetylene welding with local preheat, requires less preheat, hence provides greater freedom from warping and cracking. The procedure, in outline, consists of cleaning the defective area, preheating to a cherry red, tinning, welding, slow cooling and grinding flush. Where color matching is important, a rod providing the proper color match must be used.

Other Methods of Repair

Although this article is primarily concerned with the repair of castings by welding, there are other methods which can be used that should not be overlooked in the interest of efficient repairing. Sometimes welding is combined with these nonwelding methods.

Where there are imperfections in machined surfaces requiring a smooth finish for such things as gaskets, soft soldering with a high-zinc solder is occasionally used. It is being replaced by welding with nickel electrodes in most instances, but does have an advantage of speed in the repair of larger defects.

Porous defects in areas not to be machined subsequently can be sealed by metallizing. This is of use in sealing porosity existing in welded repairs and sealing around plugged sand holes. Where porosity cannot be repaired by metallizing, a sodium silicate penetrant sealing agent can be used without danger of rusting.

In a number of instances certain mechanical methods of repair are preferred over welding, particularly in the case of threaded and non-threaded holes and small sand or blowholes in such places as crankcase or water-jacket walls. Drilled holes are either plugged or bushed, and are usually used to repair mismachined holes (oversize, eccentric, out of line, too deep, etc.). Tapped holes are also either plugged or bushed, but in this case the plug or bush must be threaded and frequently doweled. Finally, sand holes are drilled, tapped and plugged with standard pipe plugs which are then spotfaced and ground to restore the original contour. To maintain oil and water tightness, a synthetic latex oil sealing cement is used to coat the threads.

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Wrought Aluminum Alloys

by Philip O'Keefe, Assistant Editor, Materials & Methods

Aluminum is not one metal but a large family of alloys with a wide range of properties. Ductility, thermal and electrical conductivity, fabrication properties and corrosion resistance vary with composition and heat treatment just as tensile and yield strength do. Choosing the right alloy for an application can be more important than getting the best metal. An appreciation of the properties available with each of the various wrought aluminum alloys can reduce the compromise necessary in choosing the material for many products. While 20 important alloys cover most of the wrought aluminum used, it should be remembered that over 100 are available to meet specialized needs.

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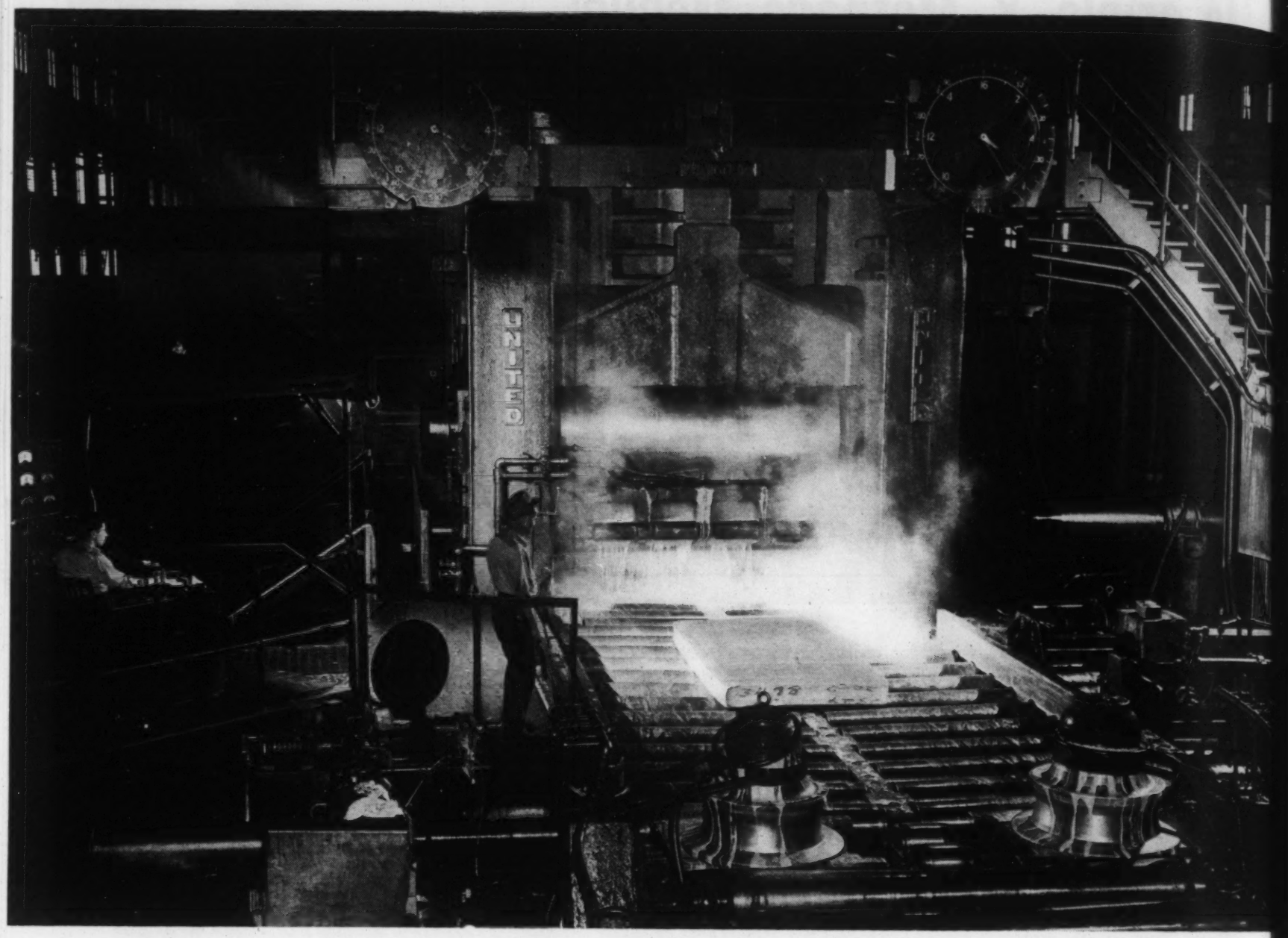


The first step in the manufacture of wrought sheet is the rolling operation, performed on a hot aluminum ingot by this 120-in. reversing mill. (Kaiser Aluminum & Chemical Sales, Inc.)

Introduction

Although aluminum is one of the most plentiful elements in the earth's crust, it was not known in its metallic state until comparatively recent times. While iron, copper, tin and zinc can be obtained from their common ores by roasting or smelting at temperatures reached in a hot fire, aluminum is held fast in its natural oxide form in the most efficient modern combustion furnaces. Globs of molten copper were beaten into crude hammers in campfires in Hungary over seven thousand years ago, and even antimony, a comparatively minor metal by modern standards, was recognized and used by Egyptians in 3000 B.C., at a time when structural aluminum was still almost five thousand years in the future.

It was actually less than 70 years ago that the Hall electrolytic process, which made aluminum an economically feasible engineering material, was discovered. Unlike most of the other metals, which are reduced from their ores by carbon or oxygen in furnaces, metallic aluminum is obtained by electrolysis of its oxide, known commercially as bauxite.

In the short time since its birth as a structural metal, aluminum has climbed to third place among the nonferrous metals in tonnage produced. The light weight of aluminum distorts the picture given by these figures, however, and a better criterion is the fact that, by volume, more aluminum is produced in this country than any other metal except steel.

In commercial parlance, *wrought* aluminum is distinguished from *cast* aluminum by the fact that its shape has been changed by mechanical working after the molten metal has been allowed to solidify in a mold. Castings are made by pouring liquid aluminum into molds, which give the metal its final shape. Diesel engine blocks and machine bases are commonly cast. Wrought products begin as hot plastic slabs or billets, which are rolled down into bars or structural shapes in hot-rolling presses. The working process improves the quality of the meal by breaking down voids and inclusion pockets to give a tough homogeneous product. Typical wrought products are plate, sheet, bars, rods, wire, tube, structural shapes, extrusions, forgings, rivets and screw machine products.

Aluminum has a number of valuable properties. Its lightness and high strength-to-weight ratio allow significant weight reductions in engineered products; less power is required for moving members; and vibration, impact and inertia stresses are lowered. The corrosion resistance imparted to aluminum by the stable oxide coat that forms in air or under special treatment gives it a tremendous advantage over other structural metals. The weight-to-electrical-conductivity ratio of aluminum has opened application fields in electric power transmission.

All of these properties can be varied by alloying, heat treating and cold working; and in actual practice a thorough knowledge of the nomenclature and characteristics of each of the many aluminum alloys and tempers is necessary to take advantage of the metal as an engineering material.

This manual is presented as a guide to the wrought aluminum alloys, to give designers and fabricators concise, accurate information on physical and chemical properties and accepted methods of manufacture. A manual on the same subject, which was published a few years ago in MATERIALS & METHODS, has been outdated in some aspects, and it is felt that the advances made since that time require this new survey.

Cost as a Factor in Alloy Selection

Metals are purchased on a weight basis, and conversion to volume or surface area is necessary to compare costs. With an aluminum alloy it may be desirable to change the design of a product or a part. The part might have to be made larger or the contour might be changed to gain strength or rigidity; sometimes the size can even be decreased or the piece incorporated with another. As a general rule, from ⅓ to ½ as much aluminum as steel, by weight, is required.

Aluminum is one of the most easily worked of all metals and, step by step, is at least comparable in cost to any of them. One highly favorable asset is that the aluminum alloys are available in almost every conceivable form. This often permits drastic changes in fabrication procedures.

The production of many products is such that the reclamation of rejections means the difference between profit and loss. Articles produced from aluminum alloys generally show high salvage values. In addition, aluminum scrap is readily sold at a high resale value.

Final cost, of course, takes all of the above into consideration. Ofttimes the cost, when using an aluminum alloy, appears to be higher than for other materials until cheaper procedures, which are generally synonymous with fabricating experience, bring the cost with aluminum to new low levels.

While original cost is of prime importance, such features as lightness, maintenance, strength, sales appeal and attractiveness play such an important role in consumer sales that it is often advantageous to employ an aluminum alloy even when the final cost of the product is slightly increased.

Prices of the various aluminum alloys vary greatly, depending upon the form, the degree of alloying, the fabricating procedures required, and the ease of production. The nonheat-treatable alloys, such as 2S and 3S, are less expensive than the "heat-treatable" alloys.

Nomenclature and Alloy Composition

While high purity aluminum has many desirable qualities, it is comparatively weak and does not respond to heat treatment. A number of alloying elements, in varying quantities and combinations, are used, and the situation is further complicated by the fact that alloy properties can be significantly changed by cold work and, in some cases, by heat treatments. A standard system of nomenclature is used to differentiate between allows and simplify selection.

Prefixes and Suffixes

Practically all of the wrought aluminum alloys contain more than one intentionally added element, as well as the normal impurities. In some alloys, as many as eight elements might be present. A simplified nomenclature system has been adopted, however, in which the principal additive element is indicated in the designation number of most of the alloys.

A wrought alloy is usually indicated by the suffix "S" following the number. The R300 series of wrought alloys are exceptions to the rule.

The prefixes "M" and "X" indicate experimental alloys. A modification of the original composition is indicated by any prefix other than "R", "M" or "X". "A" designates the first modification, "B" the second, and so on. A17S is the first modification of the alloy 17S, and B18S is the second of 18S.

Temper Designations

The wrought alloys divide into two groups—the *common* or *nonheat-treatable* and the *strong* or *heat-treatable*.

The nonheat-treatable alloys, like EC, 99.6 A1, 2S, 3S, 52S, 56S and 150S, all contain elements that either:

(1) Remain in solid solution under all conditions; or

(2) Form constituents that are insoluble in solid aluminum under all conditions.

The heat-treatable alloys all contain constituents that have considerable solubility in solid aluminum at high temperatures and limited solubility at comparatively low temperatures. The important members of this group are the high copper alloys R301, 14S, 17S, 24S, and 25S; the magnesium silicide alloys A51S, 53S and 61S; and the high zinc alloy 75S.

The strength of a nonheat-treatable alloy increases by strain hardening under cold work. When sufficient cold work has been performed to increase the tensile strength to the maximum commercially feasible, the alloy is in the fully-hardened temper. Any smaller amount of cold work produces an intermediate temper somewhere between the fully-annealed and the fully hardened condition.

The strengths of the heat-treatable alloys can be increased by thermal treatment as well as by cold work. After fabrication, they are subjected to solution heat-treatments in which the metal is heated quickly, held at a predetermined temperature to allow the soluble constituents to go into solid solution, and then quenched rapidly to prevent, or at least retard, precipitation from the supersaturated solid solution at lower temperatures.

The natural aging alloys 17S and 24S *precipitation harden* at room temperature, while the rest of the common heat-treatable alloys, although subject to various degrees of natural aging, require *artificial aging* or *precipitation thermal treatment* at slightly or moderately elevated temperatures to reach their maximum properties.

These thermal treatments result in alloys with a wide range of strengths, which may be further influenced by cold work.

The designations formerly used to indicate tempers were found to be inadequate to prescribe the stabilizing and processing cycles of some alloys. As a result, a new system of temper designation has been instituted for wrought aluminum alloys.

The temper designation, when required, follows the alloy number and is separated from it by a hyphen. It consists of a letter to indicate the basic temper, with one or more digits following it, in some cases, to define the temper conditions more specifically.

The temper designation *O* indicates the annealed condition in wrought alloys. The as-fabricated condition is shown by the letter *F*, a designation applied to products that acquire some temper qualities in the

Table 1—Chief Alloying Elements for Aluminum

Alloy Numeral Range	Chief Alloying Element
99.5	High-purity aluminum
2S	Commercially pure aluminum
3S-9S	Manganese
10S-29S	Copper
30S-49S	Silicon
50S-69S	Magnesium
70S-79S	Zinc
R301	Copper
150S	Magnesium

shaping process but are not subsequently heat-treated or intentionally strain-hardened.

The cold-worked tempers of wrought alloys are designated by the letter H, followed by two or three digits. The first digit is 1 if the temper has been produced solely by cold work.

A given level of strength can also be obtained by cold-working to a hard temper and then reducing the strength to the desired level by partially annealing. To distinguish material processed to the desired level in this way from material cold-worked to the same strength, the first digit after the H is the number 2.

Alloys 4S, B50S, 52S and 56S lose a small amount of the strength acquired by cold-work, with an attendant elongation, when they are held at room temperature for a long time. Heating the alloys for a short time at a slightly elevated temperature brings these changes to a practical completion. Such a *stabilizing* treatment is usually given to the intermediate and hard temper of commercial products in these alloys. The number 3 is used as the first digit after the H in the temper designation to indicate that this treatment has been used.

The second digit after the H, in each case, defines the degree of strain hardening. When the hardest commercially-practicable temper is produced, the digit is 8. For strain-hardening mid-way between the fully annealed and the fully hard tempers, the second digit after the H is 4. Digits 2 and 6 are similarly placed at the quarter points.

Thus, —H18 designates material that has been cold-worked to the commercial hardness limit, while —H24 indicates cold-working, followed by an anneal to the half-hard condition. Material that has been stabilized at one fourth maximum commercial hardness is indicated by —H32.

For heat-treated alloys, the temper designation consists of the letter T followed by a number of from one to three digits. The first numeral following the T shows the type of treatment used. The basic designations are:

—T2, Annealed (cast products only).

—T3, Solution heat treated and then cold worked.

—T4, Solution heat treated.

—T5, Artificially aged only.

—T6, Solution heat treated and then artificially aged.

—T7, Solution heat treated and then stabilized.

—T8, Solution heat treated, cold

Table II—Chemical Composition Limits[1]

Composition in per cent; maximum unless shown as a range

Alloy	Aluminum	Copper	Iron	Silicon	Manganese	Magnesium	Zinc	Chromium	Nickel	Titanium
EC[2]	99.45% min.	.....	....	.....	.....	.....	.....	.....	.....	....
99.6 A1	99.60% min.	0.05	[3]	[3]	.....	.....	.....	.....	.....	....
2S	99.00% min.	0.20	[4]	[4]	0.05	.....	0.10	.....	.....	....
3S	Remainder	0.20	0.70	0.60	1.00–1.50	.....	0.10	.....	.....	....
Clad 3S	← 3S sheet or tubing coated with 72S alloy[5] →									
4S	Remainder	0.20	0.70	0.30	1.00–1.50	0.80–1.30	0.10	.....	.....	....
Clad 4S	← 4S sheet coated with 72S alloy[13] →									
11S[6]	Remainder	5.00–6.00	0.70	0.40	.....	.....	0.30	.....	.....	....
14S	Remainder	3.90–5.00	1.00	0.50–1.20	0.40–1.20	0.20–0.80	0.25	0.10	.....	0.15
Clad 14S	← 14S sheet coated with 53S alloy[7] →									
17S	Remainder	3.50–4.50	1.00	0.80	0.40–1.00	0.20–0.80	0.10	0.10	.....	....
A17S	Remainder	2.20–3.00	1.00	0.80	0.20	0.20–0.50	0.10	0.10	.....	....
18S	Remainder	3.50–4.50	1.00	0.90	0.20	0.45–0.90	0.25	0.10	1.70–2.30	0.05
B18S	Remainder	3.50–4.50	0.85	0.45–0.90	0.20	1.30–1.80	0.25	0.10	1.80–2.30	....
24S	Remainder	3.80–4.90	0.50	0.50	0.30–0.90	1.20–1.80	0.10	0.10	.....	....
Clad 24S	← 24S sheet coated with 99.3% min. aluminum[8] →									
25S	Remainder	3.90–5.00	1.00	0.50–1.20	0.40–1.20	0.05	0.25	0.10	.....	0.15
32S	Remainder	0.50–1.30	1.00	11.50–13.50	.....	1.80–1.30	0.25	0.10	0.50–1.30	0.05
43S	Remainder	0.30	0.80	4.50–6.00	0.05	0.05	0.10	.....	.....	0.20
B50S	Remainder	0.20	0.65	0.30	0.10	1.00–1.60	0.25	0.10	.....	....
A51S	Remainder	0.35	1.00	0.60–1.20	0.20	0.45–0.80	0.25	0.15–0.35	.....	0.15
52S	Remainder	0.10	[9]	[9]	0.10	2.20–2.80	0.10	0.15–0.35	.....	....
53S	Remainder	0.10	0.35	[10]	.....	1.10–1.40	0.10	0.15–0.35	.....	....
56S	Remainder	0.10	0.40	0.30	0.05–0.20	4.90–5.60	0.10	0.05–0.20	.....	....
61S	Remainder	0.15–0.40	0.70	0.40–0.80	0.15	0.80–1.20	0.20	0.15–0.35	.....	0.15
62S	Remainder	0.15–0.40	0.70	0.40–0.80	0.10	0.80–1.20	0.20	0.15	.....	0.15
63S	Remainder	0.10	0.35	0.20–0.60	.....	0.45–0.85	0.10	0.10	.....	0.10
72S	Remainder	0.10	[11]	[11]	0.10	.....	0.75–1.25	.....	.....	....
75S	Remainder	1.20–2.00	0.70	0.50	0.30	2.10–2.90	5.10–6.10	0.18–0.40	.....	0.20
Clad 75S	← 75S sheet coated with 72S alloy[12] →									
R301 clad	Remainder	0.10	0.60	0.50–0.90	0.25–0.75	0.08–1.20	.....	0.10	.....	0.10
R301 core	Remainder	4.00–5.00	0.75	0.75–1.20	0.70–1.00	0.25–0.55	0.25	0.10	.....	....
150S	Remainder	0.25	0.80	0.50	0.15	1.00–1.80	0.25	0.10	.....	....

[1] *Other elements are not to be present to a total greater than 0.15%. No single element not listed is to be present in amounts exceeding 0.05%.*

[2] *Electrical conductor metal.*

[3] *Iron plus silicon—0.4% max.*

[4] *Iron plus silicon—1.0% max.*

[5] *When sheet is coated on both sides, the coatings each are nominally 10% of the total thickness; when coated on one side, the coating is nominally 15% of the thickness when the thickness is less than 0.065 in. and 7½% when the thickness is 0.065 in. or more. Tubing is coated only on the inside, and the coating is nominally 10% of the wall thickness.*

[6] *Also contains 0.2 to 0.6% each of lead and bismuth.*

[7] *The coating on each side is nominally 10% of the total thickness for sheet less than 0.040 in. thick and 5% for sheet or plate 0.040 in. or more in thickness.*

[8] *The coating is permitted to contain 0.7 iron plus silicon, 0.1 copper, 0.1 zinc, 0.05% manganese, and traces of "other elements." The coating on each side is nominally 5% of the total thickness when the thickness is less than 0.064 in. and 2½% when the thickness is 0.064 in. or more.*

[9] *Iron plus silicon—0.45% max.*

[10] *Silicon—45 to 65% of magnesium.*

[11] *Iron plus silicon—0.6% max.*

[12] *The coating on each side is nominally 4% of the total thickness.*

[13] *The coating on each side is nominally 5% of the total thickness.*

worked, and then artificially aged.

—T9, Solution heat treated, artificially aged, and then cold worked.

—T10, Artificially aged and then cold worked.

The first numeral following the T shows the type of treatment. The actual conditions will be different for different alloys; they may even be varied for a single alloy to produce certain desired results. Tempers, other than the one considered standard, or the one first used, are designated by a second numeral following the one which shows the type of heat treatment. There is no attempt to have this numeral indicate any specific set of conditions.

Just as the actual temperatures and times required to produce 61S-T6 are different from those required for 18S-T6 or 195-T6, so are those used for 61S-T61 different from those required for 18S-T61. The numeral 1 following the 6 merely designated properties different from those developed by the standard "T6" treatment for the respective alloys because there has been some modification of the conditions but not the type of treatment.

The condition that results from quenching an alloy from the solution heat-treatment temperature is unstable, since age-hardening commences immediately. This unstable condition is designated by the letter W and, since the properties vary continuously with time, it is necessary to indicate the length of the aging period in order to convey any idea of the properties. For example, 24S-W (20 min) represents a condition in which the alloy can be subjected to relatively severe forming operations; rivets can be headed, and fairly deep drawing can be done. However, the term 24S-W (4 days) would not be used, since in this length of time the age-hardening that will occur at room temperature is practically complete, and the alloy is in the stable temper 24S-T4.

Aluminum coil is reduced to final gage by cold rolling, which increases the strength of any wrought alloy. (Kaiser Aluminum & Chemical Sales, Inc.)

Available Forms

Aluminum, one of the most easily formed and worked metals, with a wide spread of alloy properties, is available in a long list of wrought forms covering most structural and product design uses. Commercial practice limits the number of alloys available in some forms, however, and care should be taken not to specify an unavailable combination.

Plate and Sheet

Aluminum that has been rolled to a thickness of 0.250 in. or greater is known as plate. Thicknesses from 0.006 in. to 0.249 are classified as sheet.

Sheet (0.102 in. or less in thickness) is produced in both flat and coil form. The methods of manufacture and handling allow a price differential in favor of the coiled product with some alloys.

Both flat and coil sheet can be furnished in several finishes. When no special precautions or extra processes are employed, the material carries a mill finish, varying from dull to bright, depending upon fabricating conditions.

Some applications require a nonheat-treatable alloy with surface luster on one side. This condition is met by a controlled finish classified as mill-finish-one-side-bright or commercial-finish-one-side-bright.

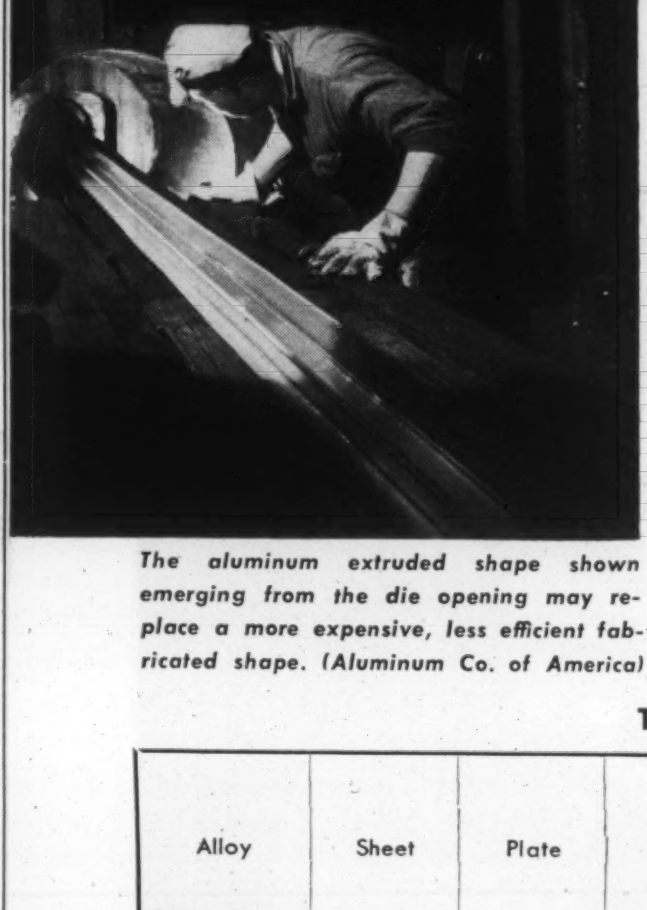
Standard-finish-one-side-bright or special-finish-one-side-bright sheet is another controlled finish with little variance between sheets. It is much brighter than the mill finish, possessing a high degree of luster and depth of brightness. Where these qualities are furnished on both sides of the sheet, the material is referred to as standard-bright-finish-two-sides or special-two-sides-bright.

The term dull finish refers to an uncontrolled dull mill finish while the gray plate finish is a controlled dull gray matte-like mill finish.

The standard bright finishes require careful production control and demand a premium price. The degree of brightness depends on the temper and the grade. The relative brightnesses, in decreasing order, are: (1) "H", or full hardened temper; (2) "O", or annealed temper; (3) H6 temper; (4) H4; and (5) H2.

The heat-treatable alloys are available only in the regular mill finish.

Several of the alloys are available in sheet form clad with high purity aluminum or an aluminum alloy that is anodic to a relatively high-strength core. This cladding



The aluminum extruded shape shown emerging from the die opening may replace a more expensive, less efficient fabricated shape. (Aluminum Co. of America)

is rolled on one or both sides.

Rod and Bar

Rod and bar stock is divided into the forging and the nonforging groups. The nonforging group sub-divides into nonheat-treatable and heat-treatable classes.

The nonheat-treatable class is furnished in the annealed and the as-fabricated condition. They possess excellent welding qualities but are inferior to the heat-treatable group in machinability. Strengths are naturally limited.

The heat-treatable class is furnished in all of the appropriate tempers. The term "screw machine stock" is sometimes used to denote a free-machining product with broader surface standards, but the term has not been accepted throughout the industry and is not widely used.

Extruded Shapes

Extruded shapes are available in many forms and alloys. Commercial sizes range in thickness from 1/16 to 14 in., with lengths varying from inches to more than 80 ft. The maximum weight of an extruded shape is generally limited to 350 lb.

Most of the nonheat-treatable alloys and some of the weaker heat-treatable alloys can be extruded through porthole dies, permitting the production of hollow extrusions in many intricate shapes. The hole for the pin in a hinge, for instance, is produced during the extrusion process by a porthole die, reducing the number of operations necessary.

Many shapes and angles can be produced from sheet material as well as by extrusion. Large complex sections might be cheaper when extruded, however.

Many standard extruded shapes are available as stock items, but if an appreciable quantity is to be used it is wise to purchase the shape most suitable. Extrusion dies often cost less than $75.00, and it is generally more economical to have them made to specifications.

Extruded shapes can be used instead of extra heavy plate when relatively narrow widths are required. This is generally preferred over the use of two plates of lighter thicknesses. The thickness of the extruded

Table III—Standard Wrought Alloy Products

Alloy	Sheet	Plate	Wire	Rod	Bar	Rolled Shapes	Extruded Shapes, Tube and Pipe	Drawn Tube and Pipe	Rivets	Forgings
EC[1]			*	*	*	2				
2S	*	*	*	*	*				*	*
3S	*	*	*	*	*		*	*		*
Clad 3S	*	*						*[3]		
4S	*	*						*		
Clad 4S	*	*								
11S			*	*	4					
14S				*	*	*	*			*
Clad 14S	*	*								
17S			*	*	*					
A17S			5						*	
18S										
B18S										*
24S	*	*	*	*	*		*	*	*	*
Clad 24S	*	*								
25S										7
32S										*
43S			*	6						
B50S	*	*								
A51S										*
52S	*	*	*	*	*			*		
53S			5						*	
56S			*	*						
Clad 56S			*	6					*	
61S	*	*	*	*	*	*	*	*	*	
62S							*	*		
63S							*	*		
72S			*							
75S	*	*	*	*	*		*			
Clad 75S	*	*								
Clad R301	*	*								
150S	*	*	*	*	*	*				

*Products marked * are produced in routine commercial production.*
[1] *Electrical conductor grade.*
[2] *Channel bus only.*
[3] *Coating on inside only.*
[4] *Available in hexagons only.*
[5] *Rivet wire only is a standard product.*
[6] *Redraw rod only.*
[7] *Propeller blades only.*

section, however, must be at least 15% of the width.

The main advantage of using an extruded shape is that almost any contour can be obtained, permitting superior engineering with a reduction of weight and minimizing costly machining operations.

Tubing

Seamless aluminum tubing is produced from hollow tube blooms extruded from drilled, pierced or hollow as-cast ingots. The blooms are fabricated to size by means of tube reducers, draw benches, or a combination of both.

The lengths of the smaller sizes of tubing are limited by the available fabricating equipment, but some sizes have been produced in 80-ft lengths. The maximum commercial straight-lengths are approximately 30 ft if subsequent thermal treatments are required.

The size of tubing is controlled by the outside diameter, the inside diameter and the wall thickness. It can be furnished with very close tolerances for any two, but not all three of these dimensions.

Tubing is obtainable in many shapes, including round, square, rectangular and tear-drop. Heavy-walled tubing can be furnished with an inside taper.

Forging Stock

Aluminum alloy forging stock is available in a variety of forms. Round sections having a diameter of ⅜ in. or more are classified as forging rod. Square, rectangular, hexagonal and octagonal cross-sectioned stock, having a greatest-distance-across-flats of ⅜ in. or more, is referred to as forging bar, while forging stock having other shapes is called forging shapes. Any forging section that is less than ⅜ in. across its greatest dimension is called wire.

Forging stock receives critical inspection, generally being caustic etched to detect even minor surface defects. The rod is usually rolled while the shapes are generally extruded. Forging bar is produced by both processes. Most rod and bar material can be furnished in either the hot- or cold-finished condition. The shapes are usually furnished in the as-fabricated condition.

Forging stock is divided into two classes. Class I is generally hot-finished and is satisfactory for most forgings. Class II is cold-finished to close tolerances for applications requiring rigid volume control.

Rolled Shapes

Many shapes can be produced either by rolling or by extruding. The large structural channels and I-beams must be produced by rolling processes. Information regarding availability and sizes should be obtained from the producers. Where either process is applicable, the quantities required are often the deciding factor.

Foil

Aluminum that has been rolled to a thickness of 0.005 in. or less is known as foil. Generally this is not recognized as a wrought product simply because the field is so complex and diversified that it has been found advantageous to consider it as a special division. Foil is commercially being produced with thickness varying from 0.00017 to 0.0059 in.

Aluminum sheet in coil form being slit into bands. (Kaiser Aluminum & Chemical Sales, Inc.)

Wire

Wire is often classified as the group containing all shapes whose largest distance-across-flats, or diameter, is less than ⅜ in. This is not strictly true since slitted wire is often considerably wider. The major portion of the wire produced is round, but special forms, such as welding wire, flattened wire, flattened and slit wire and half-round wire, are also made. One of the major uses of wire is in the manufacture of rivets.

Physical and Mechanical Properties

Since aluminum is such a widely alloyed metal, the design properties available in wrought forms give a broad field to choose from in materials selection. The properties of one basic alloy should not, under any circumstance, be memorized and used as the basis for design calculations. It cannot be overemphasized that the family of wrought aluminum alloys is extremely extensive, with rich fields for engineering applications in each branch. The materials engineer and designer must view each selection problem against the whole background.

Tension and Compression

Aluminum has no definite yield point but the yield strength, by definition, is considered to be the stress, in pounds per square inch, of cross-sectional area, required to produce a permanent set of 0.2%. In several foreign countries the term "proof stress" is employed using a permanent set of 0.1%.

The compressive yield strengths of the aluminum alloys are slightly less than the corresponding tensile yield strength. The method of testing and the shape of the specimen have a decided influence on the compressive yield strength since it is affected by the slenderness ratio (ratio of length to cross-sectional area) of the specimen. The thermal history is also important. The guaranteed minimum mechanical properties are set with these differences taken into consideration.

Elongation

One measurement of the ductility of aluminum is the ability to absorb elongation. With sheet, extrusions and similar products, the value is given as the per cent elongation in 2 in. When it is not feasible to use this gage distance, the value is measured over a length equal to four times the diameter of the test specimen.

The per cent elongation, of course, depends upon the distance over which it is measured. A test specimen from 24S-T sheet material has an elongation in 2 in. of 20%, but registers an elongation of approximately 30% over a gage distance of ¼ in. The per cent elongation is also dependent upon the shape of test specimen.

Property Range

There are several alloys and tempers available for any mechanical property range covered by the aluminum alloys. High-purity aluminum is so soft in the annealed condition that it can be cut with a knife; 72S-T6 has a yield strength twice

that of structural steel.

The choice of alloy in any mechanical property range will depend upon the form required and the other characteristics desired. Generally, the use of a nonheat-treatable alloy is advantageous whenever practicable. If the use of a heat-treatable alloy is desirable, the use of "W" or "T" tempers should be considered, since a subsequent heat-treatment is avoided.

In many applications the use of aluminum alloys in the "W" temper is feasible. 14S-T4 is finding many industrial uses where existing regulations demand that the maximum yield strength be not in excess of 80% of the tensile strength. A special aging treatment also permits the use of 61S for such applications.

The guaranteed minimum (or maximum) mechanical properties of an alloy may vary with the different products, or even between the different size-ranges of a product. This is due mainly to the manufacture and testing methods employed. A substantial portion of the variation is due to the shape of the test specimens rather than any fundamental changes in the mechanical properties of the metal.

Testing

Sheet products are tested at 90 deg (cross-grain) to the direction of rolling and straightening. The intermediate tempers of the nonheat-treatable alloys are exceptions to this rule because, in their case, the mechanical properties are slightly lower in this direction. The with-grain properties of sheet material are usually higher due to preferred orientation, elongation of the grains and the straightening and stretching operations necessary to produce a flat sheet. The intermediate tempers of common alloy sheet are tested with-grain as there is a greater fluctuation of properties in this direction. Shapes, tubing, rod, wire and similar products must be tested in the longitudinal direction.

The differences that exist between the guaranteed minimum mechanical properties of flat and coil sheet are due primarily to the elimination of the straightening and flattening operations. The mechanical properties of reheat-treated materials may be lower for the same reason.

Specific Gravity

The specific gravity of commercially pure aluminum (2S) is 2.71, corresponding to a weight of 0.0979 lb per cu in., or roughly one tenth of a lb per cu in. The following conversion factors can be used to determine the weights of the commonly used aluminum alloys and metals:

0.993 x wt of 2S=wt of 32S, A51S, 53S
0.996 x wt of 2S=wt of 61S
1.01 x wt of 2S=wt of 3S
1.02 x wt of 2S=wt of 24S and R301
1.03 x wt of 2S=wt of 14S, 17S, 18S, 25S
2.6 x wt of 2S=wt of zinc
2.9 x wt of 2S=wt of steel
3.1 x wt of 2S=wt of brass
3.3 x wt of 2S=wt of copper and nickel

Table IV—Typical Properties of Wrought Aluminum Alloys

Alloy and Temper	Ten. Str., Psi	Yld. Str. (Offset = 0.2%), Psi	Brinell Hardness, 500-Kg Load 10-Mm Ball	Shearing Str., Psi	Endurance Limit,[1] Psi
99.6-0	10,000	4,000	19	7,000	3,000
99.6-H12	12,000	11,000	23	8,000	4,000
99.6-H14	14,000	13,000	26	9,000	5,000
99.6-H16	16,000	15,000	30	10,000	6,500
99.6-H18	19,000	18,000	35	11,000	6,500
EC-0	12,000	4,000	...	.....	.....
EC-H19	27,000	24,000	...	.....	7,000
2S-0	13,000	5,000	23	9,500	5,000
2S-H12	15,500	14,000	28	10,000	6,000
2S-H14	17,500	16,000	32	11,000	7,000
2S-H16	20,000	18,000	38	12,000	8,500
2S-H18	24,000	22,000	44	13,000	8,500
3S-0	16,000	6,000	28	11,000	7,000
3S-H12	19,000	17,000	35	12,000	8,000
3S-H14	21,500	19,000	40	14,000	9,000
3S-H16	25,000	22,000	47	15,000	9,500
3S-H18	29,000	26,000	55	16,000	10,000
Clad 3S	← Properties substantially same as for 3S →				
4S-0	26,000	10,000	45	16,000	14,000
4S-H32	31,000	22,000	52	17,000	14,500
4S-H34	34,000	27,000	63	18,000	15,000
4S-H36	37,000	31,000	70	20,000	15,500
4S-H38	40,000	34,000	77	21,000	16,000
Clad 4S	← Properties substantially same as for 4S →				
11S-T3[2]	55,000	48,000	95	32,000	18,000
11S-T6	57,000	39,000	97	34,000	18,000
11S-T8	59,000	45,000	100	35,000	18,000
14S-0	27,000	14,000	45	18,000	13,000
14S-T4	62,000	40,000	105	38,000	20,000
14S-T6	70,000	60,000	135	42,000	18,000
Clad 14S-0	25,000	10,000	...	18,000	.....
Clad 14S-T3	63,000	40,000	...	37,000	.....
Clad 14S-T4	61,000	37,000	...	37,000	.....
Clad 14S-T6	68,000	60,000	...	41,000	.....
17S-0	26,000	10,000	45	18,000	13,000
17S-T4	62,000	40,000	105	38,000	18,000
A17S-T4	43,000	24,000	70	28,000	13,500
18S-T61	61,000	46,000	120	39,000	17,000
B18S-T72	48,000	37,000	95	30,000	.....
24S-0	27,000	11,000	47	18,000	13,000
24S-T3	70,000	50,000	120	41,000	20,000
24S-T4	68,000[3]	48,000	120	41,000	20,000
24S-T36	72,000	57,000	130	42,000	18,000
Clad 24S-0	26,000	11,000	...	18,000	.....
Clad 24S-T3	64,000	44,000	...	40,000	.....
Clad 24S-T4	64,000	42,000	...	40,000	.....
Clad 24S-T36	67,000	53,000	...	41,000	.....
Clad 24S-T81	65,000	60,000	...	.....	.....
Clad 24S-T86	70,000	66,000	...	.....	.....
25S-T6	58,000	37,000	110	35,000	18,000
32S-T6	55,000	46,000	120	38,000	16,000
B50S-0	21,000	8,000	36	14,000	.....
B50S-H32	24,500	21,000	45	16,000	.....
B50S-H34	27,500	24,000	50	17,000	.....
B50S-H36	29,500	26,000	54	18,000	.....
B50S-H38	31,000	28,000	57	19,000	.....
A51S-T6	48,000	43,000	100	32,000	11,000
52S-0	27,000	12,000	45	18,000	17,000
52S-H32	34,000	27,000	62	20,000	17,500
52S-H34	37,000	31,000	67	21,000	18,000
52S-H36	39,000	34,000	74	23,000	18,500
52S-H38	41,000	36,000	85	24,000	19,000

Table IV—Typical Properties of Wrought Aluminum Alloys—Continued

Alloy and Temper	Ten. Str., Psi	Yld. Str. (Offset = 0.2%), Psi	Brinell Hardness, 500-Kg Load 10-Mm Ball	Shearing Str., Psi	Endurance Limit,[1] Psi
53S-0	16,000	8,000	26	11,000	8,000
53S-T4	30,000	20,000	62	18,000	13,000
53S-T5	27,000	21,000	60	17,000	.....
53S-T6	37,000	32,000	80	23,000	13,000
56S-0	42,000	22,000	...	26,000	20,000
56S-H18	63,000	59,000	...	34,000	22,000
56S-H38	60,000	50,000	...	32,000	.....
61S-0	18,000	8,000	30	12,500	9,000
61S-T4	35,000	21,000	65	24,000	13,500
61S-T6	45,000	40,000	95	30,000	13,500
62S-0	17,000	6,500	28	12,000	8,500
62S-T4	35,000	21,000	65	24,000	13,500
62S-T6	45,000	40,000	95	30,000	13,500
63S-T42	22,000	13,000	42	14,000	9,500
63S-T5	27,000	21,000	60	17,000	9,500
63S-T6	35,000	31,000	73	22,000	9,500
63S-T83	38,000	36,000	82	.....	.....
63S-T831	32,000	29,000	70	.....	.....
63S-T832	45,000	40,000	95	.....	.....
75S-0	33,000	15,000	60	22,000	.....
75S-T6[4]	82,000	72,000	150	49,000	24,000
Clad 75S-0	32,000	14,000	...	22,000	.....
Clad 75S-T6	76,000	67,000	...	46,000	.....
Clad R301-0	25,000	10,000	...	18,000	.....
Clad R301-T3	62,000	40,000	...	37,000	.....
Clad R301-T6	68,000	60,000	...	41,000	.....
150S-0	21,000	8,500	...	14,000	12,000
150S-H22	23,500	16,500	...	15,000	12,500
150S-H32	25,500	21,000	...	16,000	12,500
150S-H34	28,000	24,500	...	17,000	13,000
150S-H36	30,000	27,000	...	18,000	13,500
150S-H38	32,000	29,000	...	19,000	13,500
150S-H18	33,000	31,000	...	19,500	13,500
150S-H19	37,000	35,000	...	.....	.....

The values given in this table are averages which take into account the variations introduced by size, shape or method of manufacture.
[1] *Based on 500,000,000 cycles of completely reversed stress using the R. R. Moore type machine and specimen.*
[2] *For sizes up to 1½ in. For larger sizes, the strengths will be somewhat lower.*
[3] *The strengths of extrusions more than about ¾-in. thick will be 15 to 20% higher.*
[4] *The values given are for sheet. Extrusions will have strengths about 8 to 10% higher.*

Table V—Comparative Strength-Weight Ratios

Material	Spec. Gravity	Density Lb/Cu In.	Ten. Str., Psi	Spec. Ten. Str.[a]	Yld. Str., Psi	Spec. Yld. Str.[b]
Aluminum (R301-T)	2.8	0.10	64,000	22,800	57,000	20,400
Stainless Steel (Austenitic 18:8 Full Hard)	7.8	0.28	185,000	23,700	140,000	17,900
Magnesium (J-H)	1.8	0.07	40,000	22,200	32,000	17,800
Cr-Mo Alloy Steel (SAE 4140)	7.8	0.28	156,000	20,000	131,000	16,800
Aluminum (24S-T)	2.8	0.10	64,000	22,800	42,000	15,000
Brass (67 Zn-33% Cu)	8.3	0.30	75,000	9,000	55,000	6,600
Structural Steel	7.8	0.28	60,000	7,700	35,000	4,500

[a] *Ratio of tensile strength to specific gravity.*
[b] *Ratio of yield strength to specific gravity.*

For wrought aluminum alloys, Young's Modulus of Elasticity is between 10,300,000 and 10,500,000 psi. The ratio of shear stress to shear strain, the Modulus of Rigidity, is approximately 3,850,000 for the aluminum alloys.

Young's Modulus for steel is roughly three times the value for the aluminum alloys, and a section of aluminum will deflect or stretch three times as much as a similar section of steel under identical conditions.

The degree of deflection is inversely proportional to the product of Young's Modulus and the moment of Inertia. Consequently, it is usually desirable to increase the moment of inertia, by employing thinner and deeper sections of aluminum alloys, when equal deflections are required.

On an equal weight basis, aluminum alloys deflect about one-seventh as much as steel. For equal deflections, the weight for aluminum is approximately one-half that for steel. Similar comparisons hold true for critical loads on long columns.

The increased deflection, by volume, of the aluminum alloys, caused by lower moduli of elasticity, is offset by their increased ability to absorb impact without permanent set, and to reduce stresses produced by fixed deflections. Their ability to absorb energy from dynamic loads is even greater. As an example, for equal elastic strengths, the strong aluminum alloys will absorb approximately eight times as much energy as steel, on a weight basis. By volume, the energy absorption of aluminum is three times that of steel.

Fatigue Strengths

The endurance (fatigue) limit of an aluminum alloy is the maximum stress that can be applied to a specimen for 500,000,000 completely reversed cycles, at a speed of 10,000,000 rpm without fracture. Fatigue values range from 5,000 psi for 2S-O to more than 22,000 psi for the high zinc-bearing alloys.

Effect of Elevated Temperatures

Aluminum alloys, like other metals, when subjected to elevated temperatures, possess lower tensile strengths, yield strengths and moduli of elasticity, and higher per cent elongations. When exposed to sub-zero temperatures, the mechanical properties and the per cent elongation of aluminum increase. Increased impact values have been reported at temperatures lower than −300 F.

Overaging or improper aging of the heat-treatable alloys may occur in prolonged exposure to elevated temperatures, resulting in impaired resistance to corrosion or changes in mechanical and physical properties. The alloys 18S and 32S, which contain nickel as a minor alloying element, possess exceptionally good resistance to corrosion at elevated temperatures. The natural aging alloys 17S and 24S often have less resistance to corrosion after short time exposures.

Erichsen Tests

The Erichsen cup test is used occasionally as a relative index of ductility, and, to a minor degree, to denote the drawability of the aluminum alloys. The values are a measurement of the gage and depth of the formed cup in millimeters. The surface of the material influences the values obtained to such a degree that they are, at best, only an indication of the ductility. The use of the test is recommended only for an indication or a comparison of properties or to obtain a quick check on grain size. Care should be taken when obtaining grain size in this manner, as clad products and heavy gages of sheet sometimes show a false grain size because of a surface layer of coarse grains.

Hardness

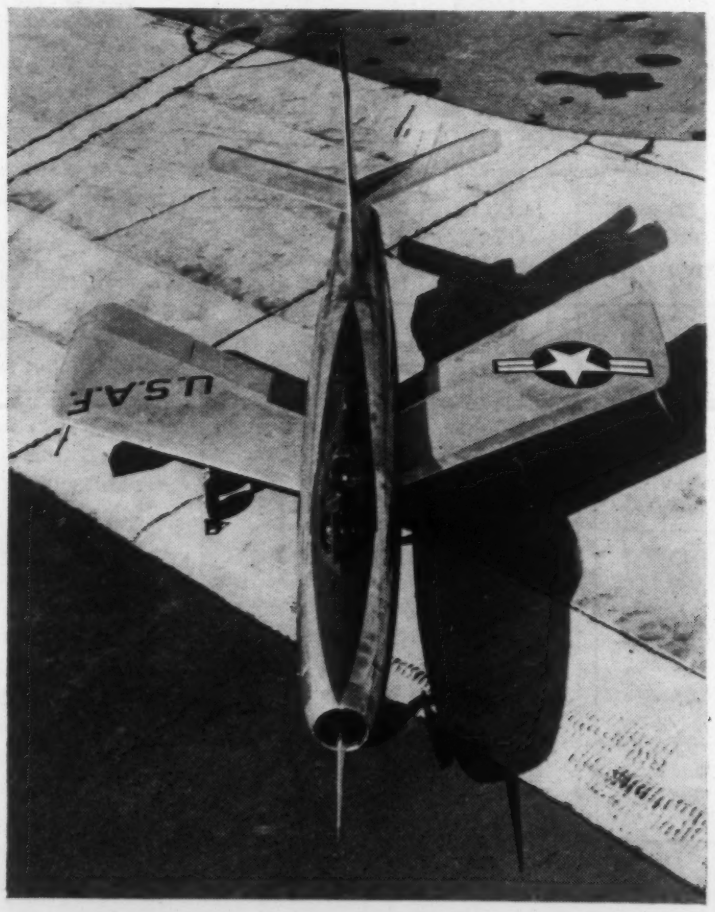
The use of various hardness tests as a control of plan heat-treatment and to distinguish between different tempers and alloys has proved successful even though the property ranges of the intermediate tempers of the common alloys overlap. The Brinell hardness test is commercially employed for forgings. Otherwise, the use of hardness tests, for other than comparison, is considered poor practice.

The hardness of a material is a measurement of many physical and mechanical properties instead of one or a few. The "strong" alloys contain appreciable amounts of alloying elements and gain a large portion of their strength by precipitation hardening. The degree of this precipitation cannot be accurately evaluated by hardness tests. In addition, clad products contain a layer of softer material which precludes the commercial use of hardness tests for determining any specific property.

There have been many attempts to correlate hardness values with ultimate tensile strengths, with varying degrees of success. The ratio of tensile strength to Brinell hardness depends on the alloy, the degree of solution of soluble constituents, and the amount of cold work. It varies from 450 to 625.

Published hardness values are those obtained with Brinell instruments employing a 10-mm ball and a 500-kg load. These values are subject to considerable error, especially near the low end of the scale. The Rockwell tester is preferred by many, and is extensively used in mill production. However, it is imperative that there is no anvil effect when testing thin gage material. The Vickers tester, the Barcol Impressor and the Webster hardness gage are also being successfully employed to secure comparative values.

On long-span power transmission lines, high purity aluminum wire with a steel reinforcing core gives a good balance between weight, strength and electrical conductivity. (Aluminum Co. of America)



A recent development was the unveiling by Alcoa of a high-strength military aircraft alloy—XA78S—stronger than 75S and based on the same alloying elements. (Republic Aviation Corp.)

Electrical Conductivities

The electrical conductivities of the various aluminum alloys depend largely upon the amount and type of the elements in solid solution, the undissolved elements, or insoluble constituents, exerting only a minor effect. Pure aluminum, by volume, has an electrical conductivity of approximately 64% of the International Annealed Copper Standard. On a weight basis, the conductivity is more than 210% of the international standard. The alloys are para-magnetic and nonsparking.

High-purity aluminum is generally employed when highest electrical conductivity is desired. Strength, if necessary, is obtained by the use of an additional aluminum alloy, or another structural metal.

The excellent weight-conductivity of aluminum is utilized in power transmission cables. Since high-purity metal is a prerequisite, the necessary strength is obtained by the use of a steel wire center. This combination permits a substantial savings in weight and expense.

Reflectivity

Many applications of aluminum utilize its high reflectivity. Highly polished high-purity aluminum is widely employed in reflectors because of its high specular and semi-specular reflectivity, the reflection factors being as high as 85%. Specular reflection allows light to be reflected where it is desired instead of being diffused over a wide area. The high thermal conductivity of aluminum disperses the heat generated by the light source, producing desirable operating conditions.

The high-purity alloys, or a common alloy clad with high-purity metal, are used when maximum reflectivity is required.

Corrosion and Chemical Resistance

Aluminum has a high affinity for oxygen, quickly forming a protective oxide film. This film, estimated to be approximately 0.0000005 in. thick, prevents further attack unless removed or penetrated by chemical or mechanical means. Since the thickness of the oxide film determines, to a large degree, the time necessary for penetration and corrosive attack, chemical and electrical methods which artificially increase the thickness of the film are widely employed to gain additional protection.

Corrosion

When aluminum and its alloys are not immune to corrosion under a specific set of conditions, control of the attack becomes important. It is desirable that corrosion be of the general pitting type, which has the least effect on mechanical properties. Intergranular corrosion can cause embrittlement and premature failure due to stress.

Practically all types of corrosion prevalent in aluminum alloys—other than chemical attack—are caused by galvanic action. The conditions necessary are at least two areas of different potentials connected by an electrolyte. Water, contaminated with chlorides or salts, is generally the electrolyte. The areas of different potentials can be dissimilar metals or alloys, constituents out of solutions, inclusions, or any nonhomogeneous material.

When corrosion occurs by galvanic action, an electric current flows from the anodic areas to the cathodic areas through the electrolyte. Corrosion occurs at the anode but not at the cathode.

Aluminum and its alloys, in the presence of an electrolyte, should not be used in direct contact with metals that are appreciably more cathodic. If practicable, the metals should be protected by paint or other suitable means. When the metals must be connected without protection, a large anodic area, in comparison to the cathodic area, should be employed.

Chromium, magnesium, silicon and manganese either increase or have no appreciable detrimental effect on the corrosion resistance of alloys. Iron, copper and tin decrease aluminum's resistance to corrosion, unless corrective elements are present.

When 24S, or any high copper-bearing heat-treatable alloy, is subjected to an improper quench, it becomes susceptible to intergranular corrosion. The impoverished zones adjacent to the grain boundaries, being anodic to both the matrix and the precipitate, are attacked. This attack quickly penetrates the metal, resulting in a serious loss of mechanical properties. The same reaction is known as interfragmentary corrosion when present in an unrecrystallized structure, which is often predominate in large extruded section. The main factors which cause a high copper-bearing alloy to become susceptible to intergranular attack are a slow quenching rate, a delayed quench and, with some alloys, heating to critical temperatures after quenching.

The clad alloys obtain their high resistance to corrosion by galvanic protection. The cladding is so chosen that it is electronegative or anodic to the core material. Attack occurs first on the cladding and does not penetrate the core until large areas of the cover metal have been removed.

The high copper-bearing alloys, such as 14S, 17S and 24S, should never be used in the annealed temper because of inferior resistance to corrosion. The alloy 24S-O, for example, seldom has more than 0.4% copper in solid solution, the remainder being out of solution in the form of the various constituents. The resulting microstructure is such that these alloys, in the annealed condition, are highly susceptible to galvanic corrosion.

A few of the high strength alloys, particularly the high zinc-bearing alloys, are susceptible to stress-corrosion cracking. In aluminum alloys, this type of attack has been proved to be the result of preferential galvanic attack, generally along grain boundaries. The use of small amounts of specific elements and the control of the precipitation processes has alleviated this difficulty and these alloys can be successfully employed for most applications.

It is suggested, however, that complete technical data be obtained when contemplating the use of the high zinc-bearing alloys or artificially aged 24S under extremely severe corrosive conditions in conjunction with exceptionally high continued stresses.

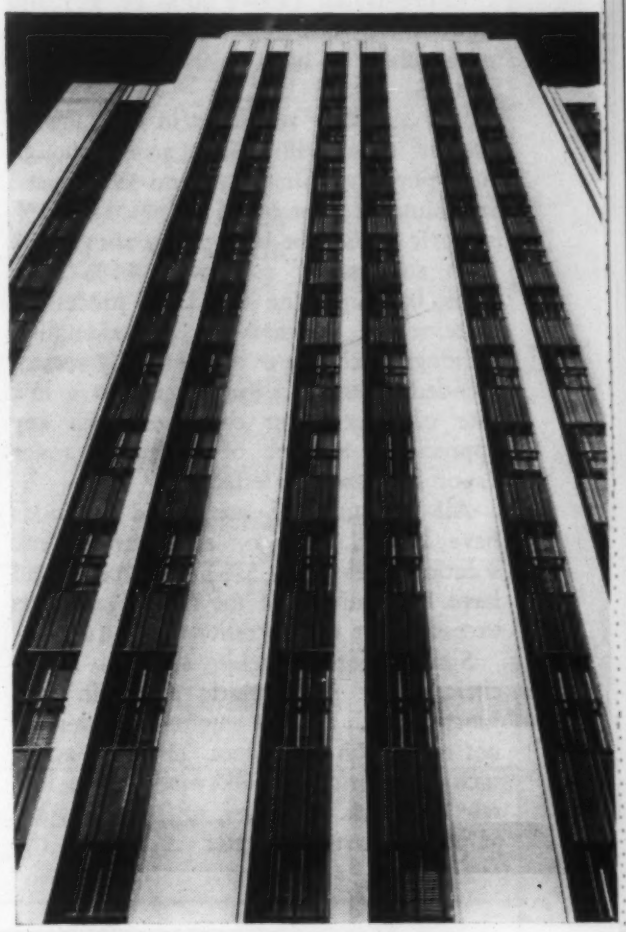
High-purity aluminum should be used when maximum resistance to corrosion is imperative. The alloy 2S is widely used because of its superior resistance to corrosion; alloy 3S has practically the same resistance as 2S when exposed to the atmospheric or to saline solutions. The alloy 52S shows about the same resistance to corrosive attack as when exposed to saline solutions.

The alloy 52S is the most corrosion resistant of the heat-treatable alloys and is only slightly less resistant to saline attack. The alloy 61S is less resistant to saline attack than 52S. Unprotected 17S and 24S are still less resistant than 61S. Clad alloys are the most resistant.

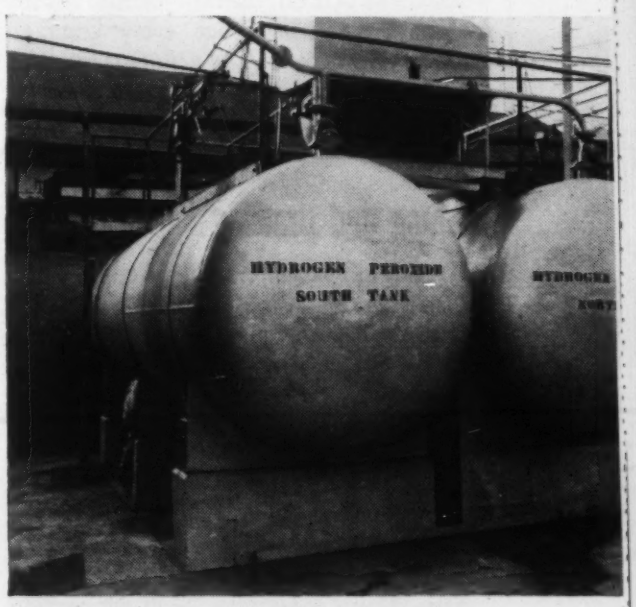
Chemical Attack

A desirable property of aluminum and its alloys is resistance to attack from many chemicals and foods. Even when they are slightly affected, the compounds formed are colorless and nontoxic.

There are many chemicals that severely attack aluminum. However, the use of suitable inhibitors, such as sodium silicate or sodium chromate, permits the use of aluminum with many of these materials.



Aluminum window frames withstand corrosion because of the dense, protective oxide film that forms on all aluminum alloys. (Aluminum Co. of America)



Aluminum tanks are used successfully to handle many corrosive chemicals. The oxide film that forms on aluminum protects the metal below. (Reynolds Metals Co.)

Dilute solutions of most mineral acids attack aluminum to some extent although successful applications with bare and coated metal are known. Special finishes help.

Concentrated (above 80% by wt) and dilute nitric acid (5% or less) have negligible effect on high purity aluminum, 2S and 3S.

The attack by sulfuric acid is somewhat greater than with nitric acid although high-purity aluminum, 2S and 3S are used in solutions containing as much as 5% sulfuric acids. The high-purity alloys have been successfully used with 15% solutions, by employing the Alrok process to increase the thickness of the oxide film, although such use is not generally recommended. Fuming sulfuric acid has a low rate of attack, but combined with any appreciable amount of water or water vapor has a serious effect.

All strengths of boric acid solutions have limited effect on aluminum. Weak solutions (less than 5%) of chromic acid have little effect but the rate of attack is excessive for concentrations over 10%.

Simple organic acids, such as acetic, citric, lactic and tartaric acids, in conjunction with a slight amount of water, do not react with aluminum. The fatty acids, such as stearic acid, likewise have a low rate of attack. However, unless a fraction of a per cent of water is present the attack may be pronounced. Uncontaminated fruit acids generally do not attack aluminum, and the addition of sugar reduces the corrosive effect of fruit juices.

Simple acids that contain a halogen radical, and formic and oxalic acids are too corrosive for most applications.

Strong caustic solutions rapidly attack aluminum. Weak solutions containing chemical inhibitors have a low rate of attack and can be satisfactorily used, if certain precautions are taken.

Ammoniacal solutions have little effect on aluminum after building up a protective surface film. Calcium hydroxide and calcium chloride, in the presence of water, are corrosive to aluminum unless an inhibitor is used. However, attack is limited by the low solubility of these compounds.

Salts composed of strong acid radicals (except the halogens) and weak base radicals usually have very little effect on aluminum. The halogen-bearing salts, such as ammonium chloride, are corrosive unless used in conjunction with an inhibitor. Ammonium nitrate and ammonium sulfate can be satisfactorily handled with aluminum.

Salts composed of weak acid radicals and strong base radicals, which hydrolyze to give alkaline solutions, should not be used with aluminum unless suitable corrosion inhibitors, such as sodium or potassium chromate or sodium silicate, are employed. High magnesium-bearing alloys, such as 56S, stand up best under this type of attack, while 3S is superior to 2S.

When aqueous solutions or liquids containing small amounts of water, contaminated with heavy metals or their salts, come in contact with aluminum, a localized pitting type of corrosion can occur. Aluminum, being anodic (electronegative) to practically all of the heavy metals, will replace them from their compounds. The replaced metals will be deposited upon the aluminum surface, causing galvanic action to occur. This attack is concentrated, forming surface pits. Eventually the small pits become holes and the aluminum must be replaced. This type of corrosion can be controlled by the addition of corrosion inhibitors or the use of clad alloys. Frequent cleaning will minimize the degree of attack.

Care must be exercised when making blanket predictions of the behavior of the aluminum alloys to all types of corrosive conditions. For example, impure sodium or calcium chloride brines, which ordinarily attack aluminum, have no appreciable effect when inhibited with sodium chromate (1% of the chloride content). On the other hand, acetic acid, which normally does not affect aluminum, can cause serious attack if contaminated with heavy metal salts.

Working Wrought Alloys

Aluminum is probably the most easily worked structural metal, being readily fabricated by just about every commercially used process. A few important characteristics of the metal must be considered to take full advantage of this universality, however.

Forming and Drawing

Aluminum has excellent cold formability, its crystalline structure being the face-centered cubic type, in common with most of the ductile metals. An index of the formability can be obtained from the tensile strength, the yield strength and the per cent elongation. The high tensile and yield strengths require more power for forming; a wide range between the tensile and yield strengths generally means a larger capacity for cold work.

The alloys possessing high elongation values can usually be given deeper draws than those with low elongations. However, care should be exercised when judging an alloy solely on the per cent elongation—there are many drawing operations where an increase in the tensile strength is more important.

The rate of strain-hardening should also be considered. As a general rule, increasing the amount of alloying elements increases the rate of strain-hardening. 52S, for example, requires the use of more power and less reduction-per-draw than 2S or 3S.

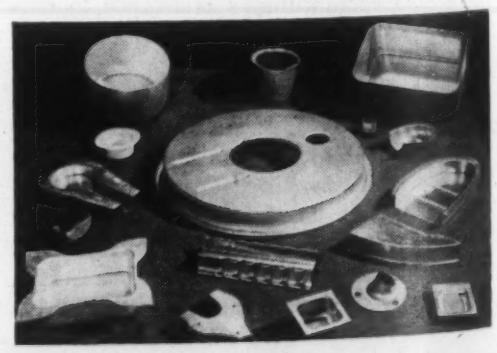
In the aluminum industry, the term forming indicates a change in shape without appreciable change in thickness. Since there is no change in cross-sectional area, the material is not severely work-hardened and usually does not require an anneal.

The term drawing is associated with a substantial reduction in the cross-sectional area of the material. The materials work-harden, increasing the mechanical properties and decreasing the workability. The reductions per draw must, therefore, be successively decreased for the first few draws.

The minimum radii used is an important factor in forming aluminum alloys. The use of suitable radii cannot be overstressed. Usually more liberal radii are required than are necessary for steel. The choice of alloy often depends upon the minimum radius required in the forming and drawing procedures.

The aluminum alloys are easily worked at elevated temperatures. Practically all hot forming, however, is confined to forgings and similar products. With sheet and tubing, the hot forming operations are so expensive that they are avoided except for

Up to 50 lb per wheel can be saved by aluminum truck wheel disks, forged for strength and dependability. (Aluminum Co. of America)



A comparison of aluminum and steel parts illustrates how easily aluminum can be formed by every commercial metal working process. (Glenn L. Martin Co.)

special applications. An important exception is the use of heat in stretch forming, with which the aircraft industry has been very successful in producing difficult shapes with the high strength alloys.

Heating to temperatures less than 650 F does no harm to the annealed temper of any alloy, although the strain-hardened tempers, of course, lose some of their strength. Exposure of the magnesium-silicide type heat-treated alloys to high temperatures can cause a slight loss in mechanical properties but does not appreciably affect resistance to corrosion.

Exposure of the high copper-bearing heat-treatable alloys in the "W" (heat-treated) or "T" (heat-treated and aged) condition can impair the mechanical properties and make the alloys susceptible to serious intergranular corrosive attack.

Pure aluminum and several of the common alloys lend themselves to the impact extrusion process for the production of thin-walled symmetrically shaped containers and similar products.

Blanking, piercing and perforating operations are easily performed with aluminum alloys. When blanking, the clearance between the punch and die should be such that approximately ⅓ the thickness of the metal is cut, with the rest being sheared. As a general rule, the diameter clearance should be from 2/10 to 3/10 the sheet thickness.

Some of the common or nonheat-treatable alloys, such as the high-purity alloys, 2S, 3S and 150S, are easily spun. The high-purity alloys and 2S do not require an intermediate anneal. The alloys 3S, 150S and 52S require more breakdowns and an anneal on deep forming operations.

Forging

Several of the alloys which possess excellent mechanical properties, resistance to corrosion, machinability and forging characteristics are widely used in forgings. The commonly employed alloys, in groups of decreasing forgeability are:

A	A51S	B	18S	C	17S
	70S		53S		14S
	25S		32S		

The listing is relative since the position in each group depends upon the type and kind of article, and the forging equipment and conditions.

Alloy 18S is used where good performance at moderately elevated temperature is required, with alloy 32S being employed when a low coefficient of expansion is an additional requirement. Alloy 53S is easily forged, and possesses moderately high mechanical properties. Alloy A51S is of moderate strength and possesses exceptional forging characteristics. Its resistance to corrosion is superior to 17S. The mechanical properties of 53S are slightly less than A51S but it offers excellent resistance to corrosion and good weldability.

Alloy 75S is used where extremely high mechanical properties are required. Its resistance to corrosion is good. Alloy 14S offers high strength with relatively good forgeability with a corrosion resistance comparable to 17S. Alloy 17S is weaker than 14S but machines better. Alloy 11S is employed when maximum machinability is required.

Machining

Most of the wrought aluminum alloys possess excellent machining characteristics, different from those for copper, brass or steel. Under ideal conditions, the free-machining aluminum alloys will machine ten times faster than steel. Usually the rate of machining is limited only by the available equipment.

Tools should be ground so that a slicing action is obtained, with considerably more side and top rake being necessary for aluminum than for steel. Clearance should be enough to prevent rubbing, although too large a clearance will cause chattering. A clearance of 7- to 10-deg is generally found satisfactory.

Carbide-tipped or high-speed steel tools are recommended for production work although plain carbon steel tools can be used. Regardless of the type of tool, the cutting edge must be kept free of scratches and burrs, and a generous supply of cutting coolant is necessary.

Medium to fine feeds should be used when a smooth surface is required, as heavy feeds increase the heat formation, causing poorer work. For most lathe work, a round-nosed tool having a 40- to 50-deg top rake with 8- to 10-deg clearance, set on or slightly above the work center, will perform satisfactorily. A side rake of 10- to 20-deg produces a smoother surface. An elliptical-nose tool with a top rake of 20-deg and a side clearance of 10-deg is generally satisfactory for removing a large amount of stock.

Table VI—Minimum Bend Radii

Minimum Recommended Radii for 90-deg Bend (In groups of increasing radii)

A	High-Purity Aluminum	E	61S-W
	2S-0		3S-H16
	3S-0	F	53S-W
	53-0		61S-T4
	52S-0		A17S-T4
B	61S-0		52S-H16
	R301-0		2S-H18
	17S-0	G	53S-T4
	Clad 24S-0		3S-H18
	24S-0		52S-H18
	R301-0	H	R301-W
	24S-0		17S-T4
	2S-H12	J	R301-T4
	3S-H12		Clad 24S-T4
	2S-H14		24S-T4
C	3S-H14	K	Clad 24S-T9
	52S-H12		24S-T9
D	2S-H16		Clad 24S-T81
	52S-H14		Clad 24-T86

Minimum Recommended Radii in Terms of Thickness for 90-deg Cold Bends

Group Classification	Gage		
	Up to 0.065	0.065 to 0.129	0.129 to 0.250
A	0	0	0
B	0	0	0–1t
C	0	0–1t	½t–1½t
D	0–1t	½t–1½t	1t–3t
E	0–1½t	½t–2t	1t–4t
F	0–2t	1t–3t	2t–4t
G	½t–3t	1½t–4t	3t–6t
H	1t–4t	2t–5t	3t–6t
J	1½t–5t	3t–6t	4t–7t
K	2t–5t	3t–6t	5t–7t

Joining Aluminum

Wrought aluminum alloys can be joined by most of the methods used commercially. Riveting is the most common process and has the broadest field of application and the maximum flexibility at the present time. Aluminum welding, brazing and adhesives in advanced stages of development are widely used. Continuing progress in these fields of joining extends the usefulness of aluminum alloys.

Riveting

Rivets are produced in the following alloys: 2S, 3S, 17S, A17S, 24S, 53S, 61S and 56S. While it is desirable to use rivets of the same alloy as the parts being joined, the alloys 2S and 3S are used for riveting most of the common alloys. 52S should be joined with 53S rivets; the heat-treatable high copper-bearing alloys can be joined with 2S, 17S and A17S rivets. Pureclad 24S should preferably be joined with 53S rivets because of excellent resistance to corrosion, while magnesium alloys should be joined with 56S rivets.

Riveting is done by normal procedures. Holes for riveting should provide 0.010-in. clearance over the rivet to be used.

Welding

All of the aluminum alloys can be satisfactorily joined by spot welding. In cases where corrosion is severe it is usually advisable to use a cladded sheet product if an exceptionally strong alloy is desired.

The butt and flash types of welds are inferior to spot welding when employing the high copper-bearing alloys because of their impaired resistance to corrosion. Seam welding is, of course, a special type of spot welding.

Gas welding and arc welding are recommended for high-purity, 2S, 3S, and 53S and 61S, and 52S in the order given. It should be kept in mind that the welds in 53S and 61S will not have the strength of the parent material, even after heat-treatment, due to the as-cast structure of the weld. Resistance to corrosion is only slightly impaired, however. The tempers of the common alloys will also lose strength due to the annealing effect of the flame.

The high copper-bearing alloys can be successfully joined by special welding methods, but strength and resistance to corrosion are greatly impaired. Distortion might be excessive and heat-treatment is usually a necessity.

The oxide film that is always present on the aluminum alloys must be removed before a sound weld can be made. This can be accomplished by the use of a flux or, in the case of resistance welding, by mechanical means.

Gas Welding

Gas welding, including oxyhydrogen and oxyacetylene, is applicable to materials 0.032 in. or over in thickness, particularly where gas-tight welds are required. Thinner materials should be resistance or seam welded.

Gas-welded joints of strain-hardened or heat-treated material will not have the strength of the parent material due to the annealing effect of the flame and the structure of the weld. The strengths of the heat-treatable alloys can be partially restored by reheat-treatment, although some warping may occur. There is no feasible way to increase the strength of welded common alloys.

Edge preparation is similar to that required for steel. No preparation is necessary for thicknesses up to 0.125 in., when the material is joined with a butt-type weld. Sheet material up to 0.064 in. in thickness can also be joined with a flange-type weld. With this method of welding, the flange is melted down with little or no welding rod used. Unbeveled butt-type welds can be made on sheet material up to 0.125 in. in thickness, although it is advisable to notch the heavier gages with a saw or chisel to facilitate full penetration. Material of over 0.125 in. thickness should be beveled.

Thick material should be preheated to a temperature of 500 to 700 F to prevent cracking and reduce gas consumption due to the high thermal conductivity of aluminum. Thin sections should be warmed to prevent cracking.

The greatest difficulty a welder inexperienced in aluminum has to overcome is the failure of the deposited metal to adhere to the base material. This is attributed to the use of an improper base temperature. To produce a satisfactory weld, the base material, protected by flux or an inert gas, must be in a molten condition at the time the molten filler rod is introduced. The welding flame should be neutral.

Too much cannot be said regarding the correct use of the proper flux. The flux is so prepared that the oxides are removed by chemically combining with it. The copious use of flux will retard the oxidation of the molten metal and will dissolve the oxides that do form. Any appreciable amount of entrapped oxide will cause a weld to be defective.

The fluxes used are extremely corrosive to aluminum and must be removed immediately. This can be accomplished by boiling water or steam or by immersing in a cold dilute nitric acid or a warm 5% sulfuric acid solution.

Arc Welding

Aluminum lends itself readily to the various forms of arc welding, employing both a.c. and d.c. machines. By far the most popular form is the metal-arc process. This concentrates the heat in a limited area preventing excessive expansion and minimizing distortion. Material thinner than 0.040 in. is difficult to weld by this process. Where gas-tight joints are required, the minimum recommended thickness is 0.187 in.

Little edge preparation is necessary for arc welding. Material thicker than 0.250 in. should be beveled from 60 to 90 deg when butt-welding. A backing strip of copper, steel or asbestos, containing a half oval groove, is a prerequisite for a uniform weld surface. The use of heavily flux-coated electrodes is imperative to control the arc. The flux forms a low density slag, stabilizes the arc, prevents excessive oxidation, and removes the oxides that are formed. It should be removed by one of the methods already discussed. It is desirable to preheat the heavier gages to a temperature between 250 and 400 F.

Only a short arc is necessary; it is desirable to keep the arc length under 3/16 in. The electrode should be the positive pole type. Current requirements are approximately proportional to the thickness of the material being welded when the proper size electrode is employed, with 0.125-in. material requiring a current of about 80 amp. When the weld penetration is insufficient, the amperage should be increased or the welding speed decreased. An excessively high current or a slow welding speed will burn the material.

Inert Gas-Shielded Arc Welding

The inert gas-metal arc welding process has several advantages over gas welding and other arc welding techniques. It requires no flux, thus eliminating back chipping and the problem of flux removal, and gives sounder welds with higher weld properties to assure pressure tight joints. The welding is accomplished with increased speeds and can be done in the vertical and overhead positions with much the same facility as horizontal welding. In addition, the technique requires a minimum of training to qualify shop personnel for high quality production welding. The processes can be adapted to mechanized welding.

With a tungsten electrode, welding is accomplished with alternating current, the arc being shielded with helium or argon gas. A superimposed high frequency circuit is used to strike the arc and maintain the arc stability. The high frequency current can flow throughout the entire welding cycle or only for a few cycles to aid in establishing the arc. Filler material is added manually when a hand torch is used or automatically with a mechanized unit. Gas is controlled automatically to coincide with the arc operation and is introduced through a nozzle in the electrode holder. Materials as light as 0.40 in. can be welded manually. While heavier materials up to thicknesses of 2 in. have been welded with this process, it is usually impractical. Due to its high thermal conductivity, the welding of aluminum plates should be limited to a maximum thickness of 3/8 in.

A consumable aluminum alloy electrode uses a direct current with reverse polarity and either argon or helium gas. Both gas flow and arc length are automatically controlled. Due to the high current densities which are used, material thicknesses of less than 3/16 in. are not recommended

for this process. The high current densities, however, are advantageous for welding thick plate since preheating is eliminated and fewer weld passes are required.

Spot Welding

Spot welding, a form of resistance welding, is applicable to all of the aluminum alloys. The high thermal and electrical conductivities of the alloys require the use of an extremely high welding current and an extremely short discharge time.

An electrode pressure of 58,000 psi before and after welding and 23,000 psi during the welding process is recommended for general use. The current requirements are between 13,000 and 36,000 amp, depending upon the alloy and the thickness of the material. The discharge times will vary from 4 to 15 cycles.

The protective oxide film should be removed from the surface of the alloys, with the possible exception of 2S, 3S and the high-purity alloys, to prevent electrode pickup and to produce consistent welds. The oxide can be removed with steel wool, emery cloth, rotary wire brushes, hot caustic solution or a number of commercially prepared cleaners.

Butt and Flash Welding

With the butt welding method, the pieces of material to be welded are kept in contact under constant pressure. When current is applied, melting occurs at the intersection, producing a weld. This method is applicable only to simple cross sections.

Flash welding is similar except that the current is applied while the pieces of metal are coming in contact with each other. Melting occurs during the sparking or flashing period, with fusion taking place immediately afterwards. This is applicable to almost any type of cross-section.

Aluminum Brazing

Aluminum brazing is the commercial name for a joining process which employs a high silicon-bearing, low-melting aluminum alloy. The structure to be joined is heated by torch or in a furnace to such a temperature that the low melting alloy, in the form of wire, sheet or cladding, melts, forming a weld between the parent materials. The process is applicable to the nonheat-treatable alloys and most of the magnesium-silicide type alloys.

This method of joining is relatively inexpensive, strong, can be employed with thin gage material, and has little effect on the resistance to corrosion. The strong alloys can be heat-treated after brazing if additional strength is necessary.

Aluminum Soldering

A large number of solders and fluxes are marketed which can satisfactorily solder aluminum. However, no single solder or flux is suitable for all applications as their wide range of melting points, chemical activity and compositions will have varying effects on the different aluminum alloys. A strength range of 1500 to 10,000 psi in sheet can be attained with aluminum soldered joints having varying degress of corrosion resistance. Due to the compositions of the solders, the inherent possibility of galvanic corrosion in outdoor and other corrosive media requires careful considerations for such applications if protective coatings are not used.

Adhesives

The art—for it is an art—of joining aluminum by "gluing" is rapidly becoming popular. By the use of proper adhesives, metal-to-metal bonds having shear strengths as high as 5500 psi have been consistently produced.

At present, most of the materials are expensive and deteriorate after several months storage. Their resistance to heat is limited, precluding their use in many applications.

In spite of certain temperature and strength limitations placed on their use, the adhesives are effective in joining metal-to-metal and metal-to-nonmetallic material. Their use, while perhaps not to be stressed, should be given due consideration.

Finishes for Aluminum

Appearance is a very important feature of any metal product. Aluminum's natural surface is sufficient for many applications, but a variety of commercial finishes are also available for special corrosion resistance or appearance problems.

The finishes applicable to aluminum and its alloys can be sub-divided into the following groups:

(1) Mechanical Processes—for altering the appearance of the surface. Finishes such as grinding, sandblasting, hammering, tumbling, buffing and coloring, scratchbrushing and satin finishing fall into this classification.

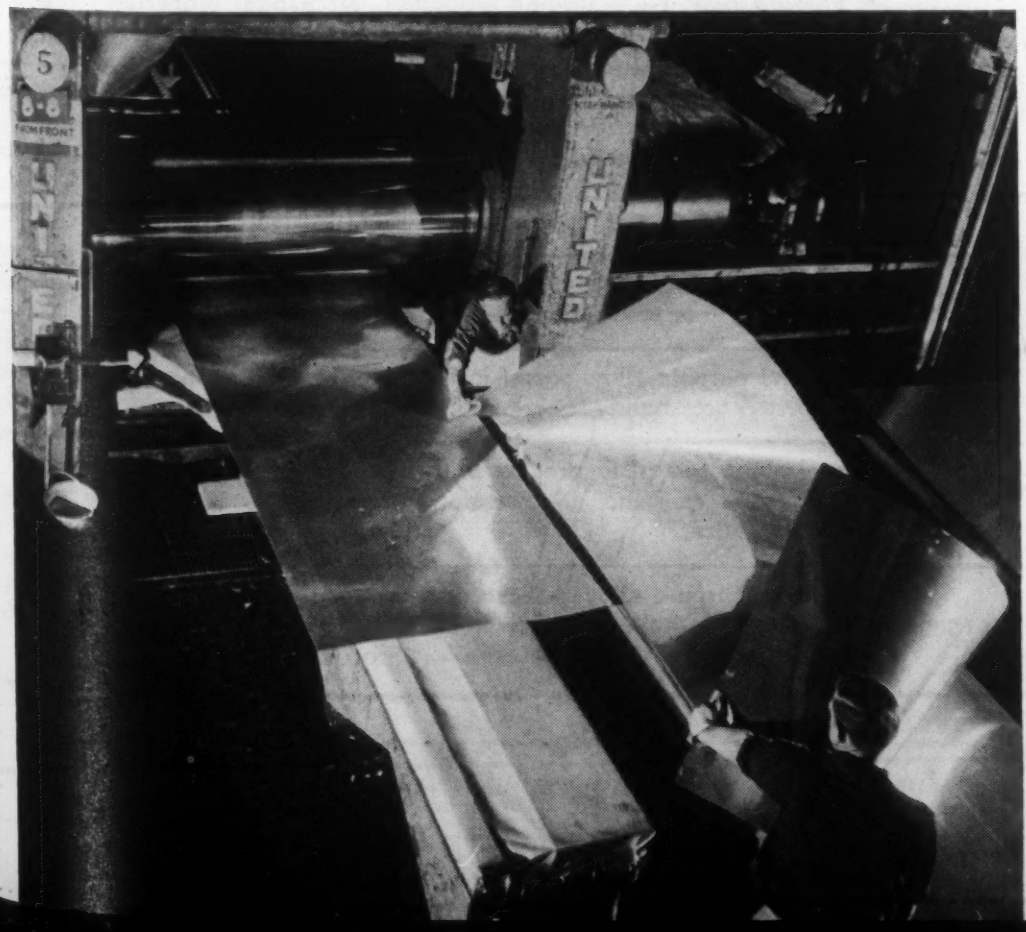
(2) Inorganic Chemical Finishes—There are numerous chemical and electrochemical processes suitable for aluminum. Included in this group are such processes as etching, Alrok coatings, Alumilite, Anodizing, Alzak coating and electroplating. Several are patented and licensed processes.

(3) Organic Finishes—This classification includes such finishes as lacquers, enamels, varnishes, paints and vitreous enamel coatings.

The majority of the mechanical finishes decrease resistances to corrosion because of the abrasive effect on the metal surface. Highly polished surfaces, however, possess an increased resistance to corrosion. Where the continued surface appearance is important, it is advisable to use an additional protective treatment.

Most of the chemical and electrochemical finishes are processes which produce a dense adherent oxide coating on the aluminum surface. The Alrok process employs a hot, weak solution of sodium carbonate

High surface finish is given to aluminum sheet in a skin pass mill. In many applications, no chemical finish is required on aluminum alloys. **(Kaiser Aluminum & Chemical Sales, Inc.)**



and potassium dichromate. When a denser and harder coating is needed, the anodizing process is employed. Anodizing, which produces an extremely hard surface of aluminum oxide (similar to corundum), is done electrochemically. The aluminum part is made the anode in an electrolyte such as dilute sulfuric, chromic, oxalic or boric acid. The type of coating formed depends upon the electrolyte, the temperature, the time and the voltage used.

Both anodized and Alroked surfaces can be further enhanced by the application of suitable dyes. The colors, generally organic, will fade upon long exposure to sunlight. For color-fast surfaces, a treatment employing mineral pigments is required.

The Alzak process is used to produce high specular and diffuse reflector finishes. With this process,, surface impurities are removed and a special surface obtained by an electrochemical treatment in a dilute solution of hydrofluoroboric acid. The surface then receives a hard oxide coating by means of an electrochemical sulfuric acid treatment. Specular reflectors made by this process have a reflectivity of approximately 85%, the diffuse reflectors a reflectivity of approximately 80%.

Aluminum can be satisfactorily electroplated, but the natural oxide film must be removed and replaced by a thin layer of zinc. This surface preparation process is known commercially as the "Zinc Immersion Process". After a thin copper layer is put over the zinc from a Rochelle cyanide type bath, any metal can be applied. A newer chromium plating process using a high-speed bath plates directly on aluminum prepared by abrasive blasting.

Paint and lacquer finishes are often desirable for aluminum alloys, with the same general rules applicable for other metals being employed. The surface should be washed or dipped in a solvent cleaner, vapor degreased, or cleaned by one of the many solutions. Many preparatory phosphoric acid type cleaning compounds are available which can be used on surfaces not subject to extremes in exposure conditions. For applications under severe corrosive conditions, an Alrok or an anodizing treatment should also be employed.

The organic finishes are commonly applied by brushing, spraying, dipping or roll coating, although almost any method can be employed.

A primer coat should be used for best adherence under severe corrosive conditions. Aluminum paint and zinc chromate are excellent primers for paint and enamel but, of course, are not suitable for all lacquer finishes. Primers containing lead are not suitable.

Almost any type of paint can be used on aluminum, although the materials more commonly employed are synthetic lacquers, synthetic enamels and aluminum paint. The transparent finishes are usually alkyd or methacrylate resins. Special low temperature vitreous enamels are now being used successfully on aluminum exterior wall facing, producing attractive, durable finishes.

The use of aluminum sometimes eliminates the necessity of painting, plating or other finishes in many applications, thus decreasing fabricating practices. Information is available from aluminum producers.

Acknowledgments

Aluminum Co. of America
Kaiser Aluminum & Chemical Sales, Inc.
Reynolds Metals Co.
The Aluminum Assn.

Table VII—Wrought Aluminum Alloys in Brief

	Nonheat-Treatable Alloys
High-Purity Aluminum	High conductivities, reflectivity and excellent resistance to corrosion and chemical attack. Strengths are limited.
2S	General purpose alloy, excellent drawing, forming and welding properties. Excellent resistance to corrosion.
3S	General purpose alloy—slightly stronger than 2S. Very good drawing, forming and welding properties. Excellent resistance to corrosion.
43S	Lower melting alloy with an appreciable amount of silicon. Used for welding rod. Modified compositions used in production of brazing sheet.
52S	General purpose alloy with medium mechanical properties. Good forming properties. Excellent resistance to corrosion in saline solutions. Welding characteristics inferior to 3S.
56S	Primarily a rivet alloy. Used for joining magnesium. Also used when high resistance to alkaline attack is required.
	Heat-Treatable Alloys
11S	Primarily a rod, bar and wire alloy. Excellent machining characteristics with medium high mechanical properties.
14S	Shapes and forging alloy. Extremely high mechanical properties and hardness. Resistance to corrosion comparable to 17S. "W" mechanical properties comparable to 17S-T.
17S	General purpose high strength alloy. Ages at room temperature. Good formability and resistance to most types of corrosion.
18S	Forging alloy which gives good performance at elevated temperature.
24S	General purpose alloy. Ages at room temperature. Possesses higher strengths than 17S with comparable workability and resistance to corrosion.
Clad 24S	In sheet and plate forms. Combines strength of 24S with resistance to corrosion of high-purity aluminum.
25S	Forging alloy. Good forging properties. Mechanical properties comparable to 17S, but more easily forged. Resistance to corrosion inferior to 17S.
32S	Forging alloy with a low coefficient of expansion and good resistance to corrosion. Good performance at elevated temperatures.
A51S	Forging alloy with excellent forging characteristics. Possesses a higher yield strength than 17S or 25S. Corrosion resistance is comparable to 17S.
53S	General purpose alloy, possessing medium mechanical properties and very good resistance to corrosion. Good welding characteristics.
61S	General purpose alloy, possessing medium physical properties. Its forming properties are slightly superior to R353. Very good resistance to corrosion.
R301	Clad sheet and plate product with mechanical properties comparable to 14S and a resistance to corrosion comparable to R361. Good forming characteristics.
150S	General purpose alloy possessing very good drawing, forming, welding and finishing properties. Intermediate strength range between 3S and 52S with corrosion resistance superior to 2S or 3S.

Materials Engineering File Facts

NUMBER 209
June, 1951

MATERIALS: Aluminum
METHODS: Fastening

Characteristics and Applications of Standard Aluminum Rivet Alloys and Tempers

Rivet Alloy and Temper as Supplied	Rivet Temper after Driving	Driving Condition and Comments	Assembly Alloy
2S — F 3S — F	— F	As received. Prolonged storage won't affect properties. Cold working from driving increases strength slightly.	2S, 3S – 0, 4S – 0, 50S – 0, 52S – 0
A17S — T4	— T3	As received. Preferred in many cases over A17S rivets.	Hard tempers of 3S and 52S, 14S, 17S, 24S, R301 and 75S
17S — T4	— T3	As received. Driven head may crack due to high pressures but won't seriously affect tensile and shear strengths provided cracks do not extend into shank area of head. Use mainly with small diameter rivets.	14S, 17S, 24S, R301 and 75S
	— T31	Immediately after reheat treating and quenching, or—store at $\left\{\begin{matrix}32\text{ F}\\-40\text{ to }-50\text{ F}\end{matrix}\right\}$ for $\left\{\begin{matrix}24\text{ hr}\\2\text{ wk}\end{matrix}\right\}$ and drive or reheat. Heat treat at 940 ± 10 F.	
	— T41	Drive hot at 940 ± 10 F after heating 15 min. Drive with random spacing to avoid overheating of surrounding metal. Generally used on large assemblies.	
24S — T4	— T31	Drive immediately after reheat treating and quenching or refrigerate for storing under same conditions as 17S, then drive. Heat treat at 920 ± 10 F.	14S, 17S, 24S, R301 and 75S
53S — T4	— T41	Drive hot at 960 to 1050 F. Ultimate shear strength increases 1000 psi every 12 F temperature rise between 960 and 1050 F. Ages to full strength in 2 wk. Use with large size rivets.	63S and 61S
53S — T6	— T6	As received. Can be stored indefinitely.	
53S — T61	— T61	As received—mechanical properties slightly lower than — T6, easier to drive. Can be stored indefinitely.	
56S — F	— H321	As received. They can be stored indefinitely.	Magnesium alloys.
61S — T4	— T43	Drive hot at 1020 ± 30 F using procedures noted for 17S — T4 rivets. Age to full strength at room temp. in 2 wk. Properties not affected by driving temperature selected.	63S and 61S
61S — T6	— T6	As received. Properties not affected by storage period.	63S and 61S

Adapted from data in "Fastening Methods for Aluminum" by the Reynolds Metals Co.

I've re-ordered

B&W ALLMUL FIREBRICK

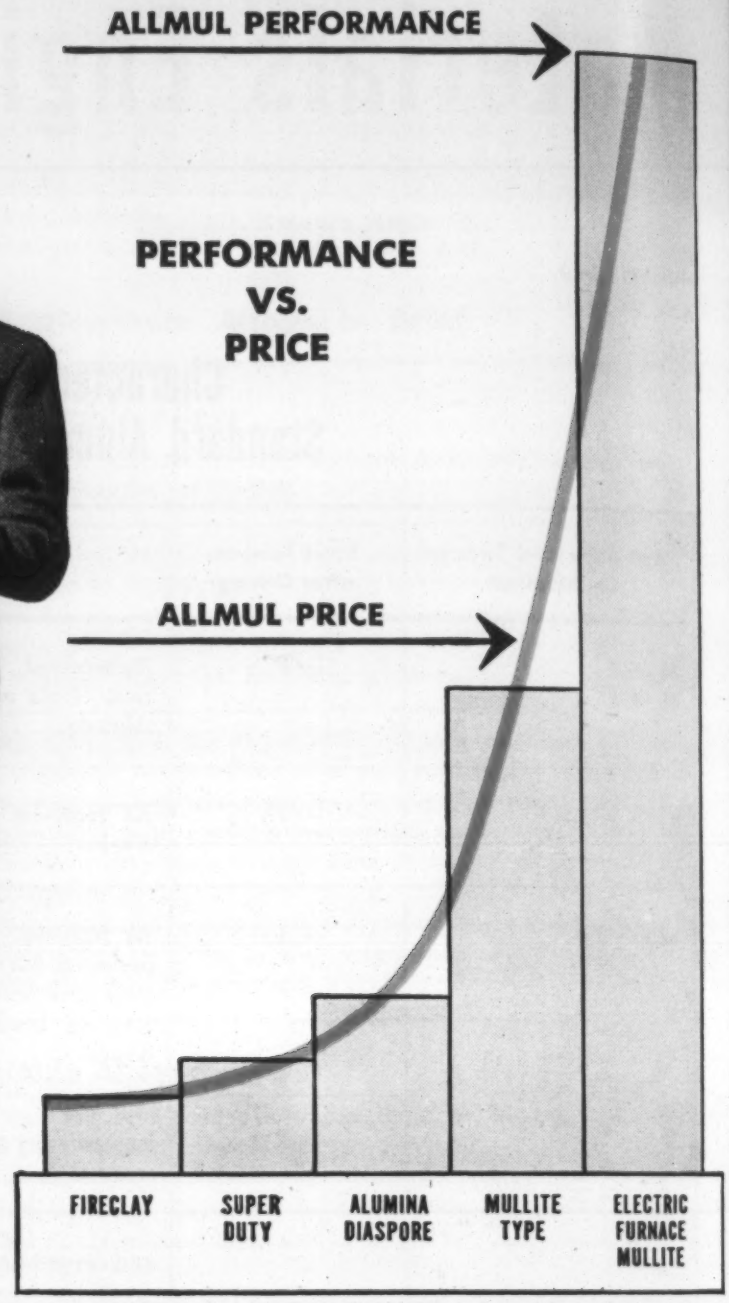
That's what scores of users are saying about B&W Allmul . . . the new, remarkable, electric-fused mullite firebrick. In plant after plant, Allmul has been *re-ordered* for such severe service applications as ferrous and non-ferrous melting furnaces, slag melting furnaces, butt-weld furnaces, glass tanks, checker chambers, ceramic kilns and many others. *That's proof of performance.*

There are two good reasons for the welcome Allmul has received. The first is its *price.* Mass-produced by a special, highly efficient process, top-quality Allmul comes to you at a price far lower than you would expect. For concrete evidence, look at the performance-price ratio charted at right.

The second reason is *staying power.* The panel below gives facts and figures . . . shows why no other firebrick in Allmul's price range can match its performance. In fact, no mullite brick at any price can better the performance of Allmul.

If you are not yet saving money with B&W Allmul, may we suggest you investigate this important new firebrick immediately. The sooner you start using Allmul, the greater your ultimate savings will be. SEND FOR NEW BULLETIN R-29.

ALLMUL is another important refractories development by B&W engineers who have continuously established new standards in industrial furnace refractories for the past 30 years.



CHECK THE PROPERTIES OF ALLMUL!

Here's how B&W Allmul stood up under standard tests.

SPALLING—12 cycles of heating to 2550F and chilling in cold air and water spray. **Result—no loss.**

HOT LOAD DEFORMATION—1½ hours at 3050F under load of 3600 pounds per square foot. **Result—less than 2% deformation.**

PERMANENT VOLUME CHANGE UNDER REHEATING—After 5 hours at 3200F. **Result—less than ½% change.**

FACT—no other firebrick in Allmul's price range can match its performance. **Fact**—no mullite brick at any price can better the performance of B&W Allmul.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: AUGUSTA, GA.

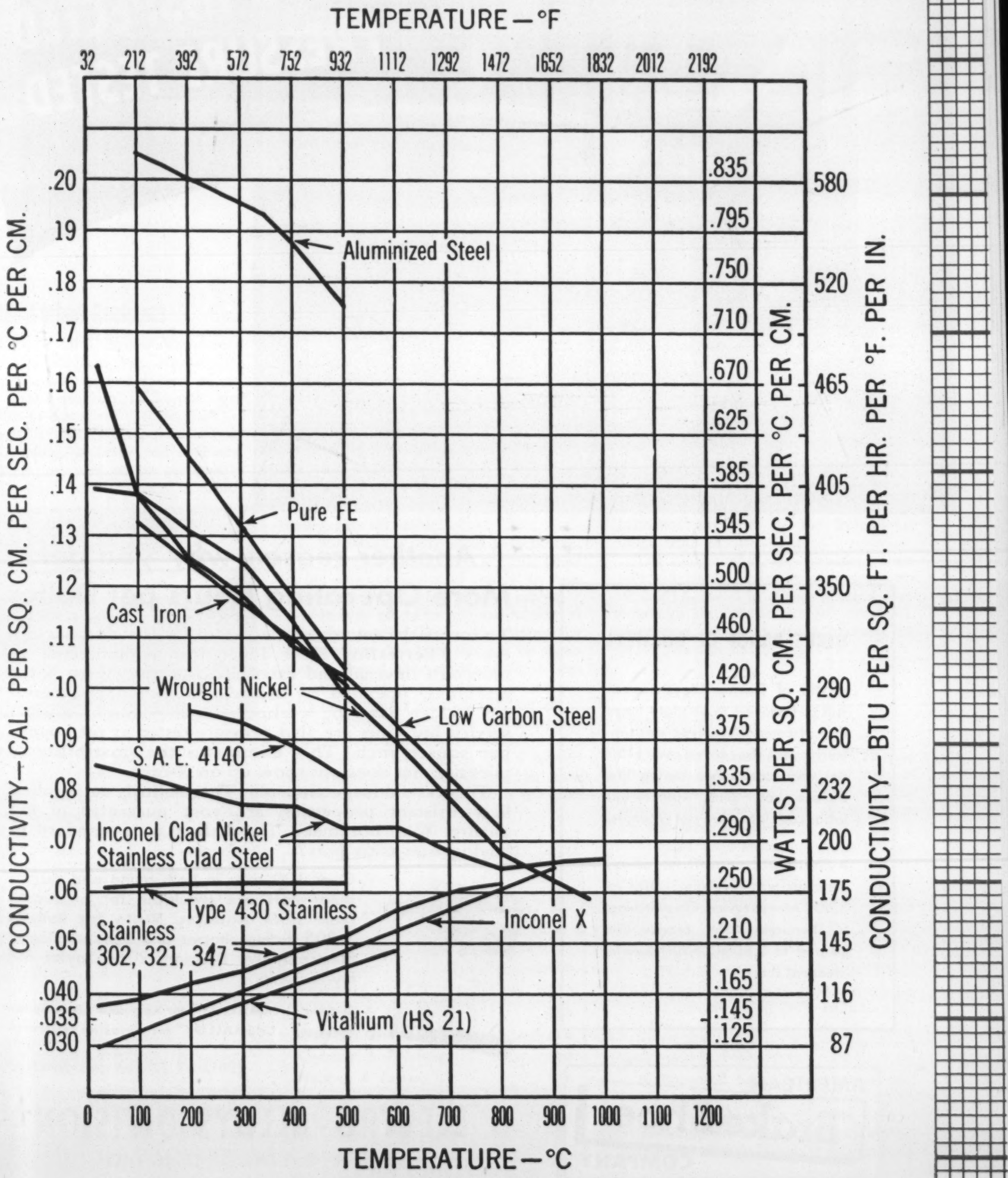
R-395

B&W REFRACTORIES PRODUCTS — B&W 80 Firebrick • B&W Junior Firebrick • B&W 80 Glass Tank Blocks • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

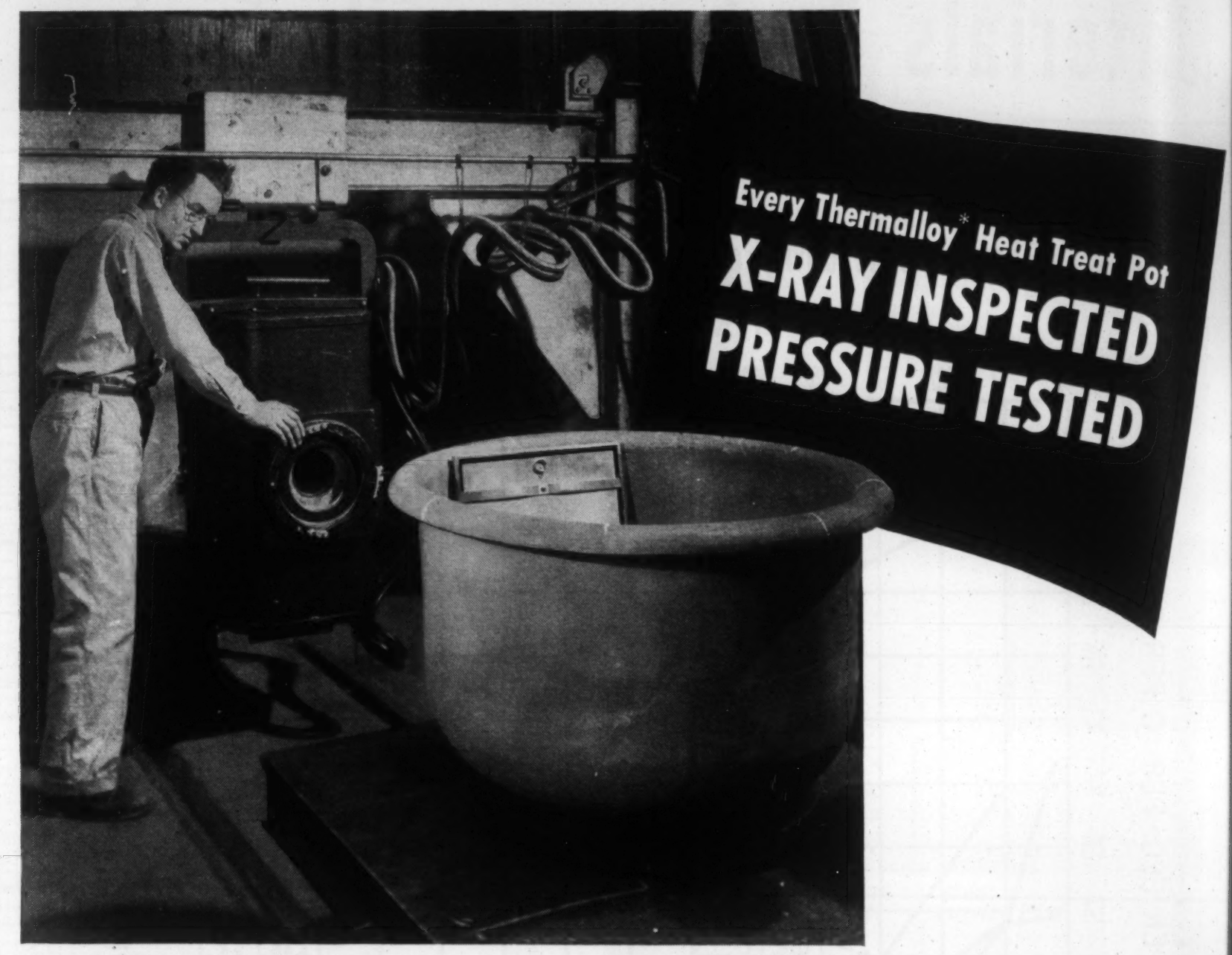
Materials Engineering File Facts

NUMBER 210
June, 1951

Thermal Conductivity of Various Materials vs. Temperatures


TEMPERATURE—°F
32 212 392 572 752 932 1112 1292 1472 1652 1832 2012 2192
CONDUCTIVITY—CAL. PER SQ. CM. PER SEC. PER °C PER CM.
.20 19 .18 .17 .16 .15 .14 .13 12 .11 .10 .09 .08 .07 .06 .05 .040 .035 .030
WATTS PER SQ. CM. PER SEC. PER °C PER CM.
.835 .795 .750 .710 .670 .625 .585 .545 .500 .460 .420 .375 .335 .290 .250 .210 .165 .145 .125
CONDUCTIVITY—BTU PER SQ. FT. PER HR. PER °F. PER IN.
580 520 465 405 350 290 260 232 200 175 145 116 87
Aluminized Steel
Pure FE
Cast Iron
Wrought Nickel
Low Carbon Steel
S. A. E. 4140
Inconel Clad Nickel
Stainless Clad Steel
Type 430 Stainless
Stainless 302, 321, 347
Inconel X
Vitallium (HS 21)
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
TEMPERATURE—°C

Courtesy of Surface Combustion Corp.



Another reason why you get
More Operating Hours per Dollar

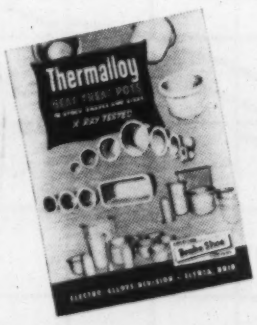
To insure the soundness necessary for low-cost service, every Thermalloy Heat Treat Pot is subjected to thorough internal and external inspection. Two X-ray machines, operated by trained radiographers, reveal any hidden flaws or weaknesses which might shorten service life. Pots are also pressure-tested at 60 pounds per square inch. This eliminates the possibility of porosity that does not show up on X-rays.

This careful inspection, plus Thermalloy's outstanding heat-resistant properties, are your guarantee of top quality. Why not make Thermalloy your standard in buying heat treat pots?

HERE'S PROOF OF QUALITY!

- Life of Electro-Alloys neutral salt pot proved to be eight times that of competitive type pot formerly used. User saved over $100 on initial cost alone during life of one pot—plus replacement labor costs of seven pot changes.

- With a competitive alloy, customer was receiving 1,500 to 3,500 hours service. On switching to Thermalloy pots, service life jumped to 3,800-5,550 hours in identical service.



Over 100 sizes in both round and rectangular pots are available for production from stock patterns. Write for Bulletin T-205, listing shapes and sizes available. Electro-Alloys Division, 2086 Taylor St., Elyria, Ohio.

Specify THERMALLOY* for heat and abrasion resistance... CHEMALLOY* for corrosion resistance

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

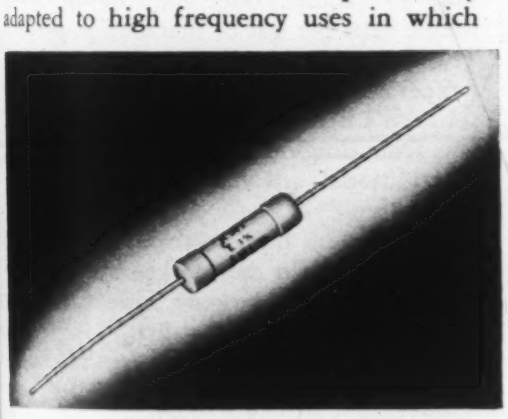
New Materials and Equipment

Materials & Parts

Deposited Carbon Resistors

The Resistor Div., *Electra Manufacturing Co.*, 2537 Madison Ave., Kansas City 8, has announced the manufacture of deposited carbon resistors in ½-watt size with values to customer's specifications.

Designed for precision applications requiring stability, accuracy and economy, the resistors are said to be particularly adapted to high frequency uses in which high stability and close tolerance of resistance are important factors.



This deposited carbon resistor is particularly adaptable to high frequency applications.

Deposited carbon resistors are supplied with 1% tolerance, and are calibrated within tolerance at 77 F. In many advanced electronic circuits these resistors are claimed to be the only choice because the characteristics of carbon compositions are unsuitable and wire wound resistors are too expensive.

Corrosion Resistant Rubber Patching

Carboline Co., 7603 Forsyth Blvd., St. Louis 5, has announced the development of a new corrosion resisting rubber patching material which, it is said, may make hazardous field rubber patching or revulcanizing obsolete.

Carbo-Flex 6040 is claimed to be a flexible, hard, crack and corrosion resistant rubber and wood adherent material which has such low shrinkage that patches stay in place.

Outstanding features claimed for the new patch material for rubber linings and lining for wood tanks are:

1. Bonds perfectly to used, vulcanized rubber. Stripping it off will pull away most grades of rubber.
2. Shrinkage is only about 1/10 of 1%.
3. Corrosion resistance is not only equal to, but superior to that of rubber. Its heat resistance is better than that of rubber.
4. Readily mixed for use and hardens at room temperature. Drying time is usually two or three days, but this can be shortened to several hours with additional catalyst and/or the application of heat by infra-red lamps or warm circulating air.
5. It possesses sufficient flexibility for most services, except belt repairs.

Carbo-Flex, however, is not a rubber-base material and should not be used where the resiliency of rubber is required.

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Synthetic Rubber Compound

O-rings and other precision molded seals can be obtained in a newly developed extreme temperature range synthetic rubber compound, according to the manufacturer, *Parker Appliance Co.*, 17325 Euclid Ave., Cleveland 12.

Resistant to non-fuel petroleum products, such as lubricating oils and hydraulic fluids, the new compound, Parker 42, is said to function effectively in sealing performance anywhere in the temperature range from –85 to 275 F.

The compound is also suitable for service with ozone, having an ozone resistance of 0.003% for 6 hr. Other physical characteristics are: tensile strength, 2000 psi; elongation, 300%; Shore A hardness 60, ±5 F; permanent set, 3%.

Steel Alloys

Uniworld Research Corp. of America, Cleveland, has announced a new series of electro steel alloys. According to company reports, the new rustfree steels possess the following properties.

1. High yield strength: tensile strength ratio of 75,100: 95,300 psi in the hot rolled, fully annealed condition.
2. Fully austenitic, nonmagnetic structure even after severe cold working.
3. Moderate hardness of 82 rb in the annealed condition.
4. High ductility: The alloy is claimed to have an elongation of 49% and a reduction in area of 64.5% in the fully annealed condition.
5. High tensile strength at elevated temperatures.
6. Improved corrosion resistance especially against different concentrations of sulfuric acid. Generally speaking, SR steel alloys range in the A classification when exposed to these solutions at room temper-

New Materials and Equipment
(CONTINUED)

ature and in the B classification when exposed to these solutions at elevated temperatures.

Plastic Casting Compound

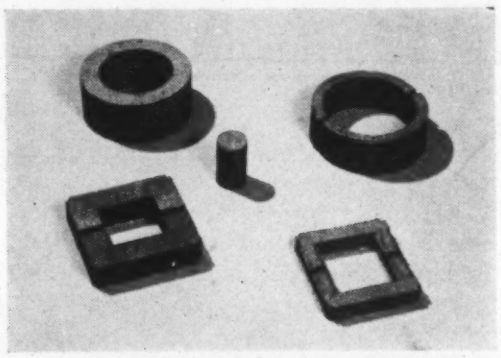
Recently announced by *Furane Plastics, Inc.*, 719 W. Broadway, Glendale 4, Calif., a new casting compound, Calcerite-B, is said to possess good physical properties and high temperature stability in addition to being offered to the trade at prices up to 30% lower than previous grades.

Amino-aldehyde resins comprise the basic plastic materials in the manufacture of the new formulation. The resin solids and fillers activated by water, set at room temperature, require curing at 120 to 140 F to develop optimum properties. Forming clean, hard working surfaces, Calcerite-B is finding important applications in production tooling, checking fixtures, embossing tools, patterns and dies for duplicating machines.

Noncritical Ferrites

Availability of high permeability ferrite parts using noncritical materials has been announced by *Ferroxcube Corp. of America*, 50 E. 41st St., New York 17.

Transformer cores, deflection yoke cores, antenna cores and permeability tuning



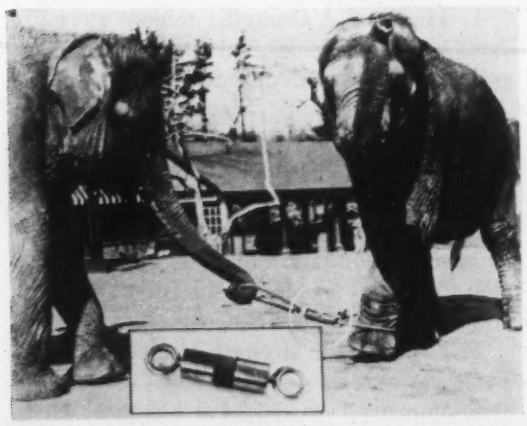
These high permeability ferrite parts use noncritical materials.

cores for television and electronics are now being offered in Ferroxcube 3 and 3C materials, all of which are said to be nickel-free.

Coatings & Finishes

Bonding Primer

A new development said to make possible a bond between silicone rubber and metals or ceramics that is stronger than



Silicone rubber can be so firmly bonded between two pieces of steel with the new primer that more than 1500 lb must be exerted to break the seal.

rubber has been announced by the Chemical Dept. of *General Electric Co.*, Pittsfield, Mass.

Designated G-E 81267 primer, the new product is a thin, light-colored liquid. By using it, G-E silicone rubber 81223 can be bonded to almost any surface. Bonds to glass, ceramics, aluminum, steel, tin and copper are also claimed to be possible, and sheer strength measurements of bonds on steel are approximately 700 lb psi.

The technique of applying and using this primer is said to be simple and to easily fit into the fabricating technique now employed with the newer G-E silicone rubber compounds.

According to the manufacturer, the development of the new primer now makes possible a wide variety of silicone rubber-to-metal molded products which include shock and engine mounts that resist both high and low temperatures. Also, improved rubber-glass laminated structures are now possible, and G-E's new high-strength silicone rubber in conjunction with G-E 81267 primer can be used as an adhesive.

Lacquer for Polystyrene

A new lacquer for finishing polystyrene products, believed to be the first that provides a lasting, smooth coating to the plastic, has been developed by *United Lacquer Manufacturing Corp.*, Linden, N. J.

Base C 5123 can be applied with standard spray equipment, and is said to provide good adhesion and a high degree of durability. Other lacquers available before this one have attacked the polystyrene and caused minute cracks and wrinkles, company chemists explained.

The new coating is available in all colors, in gloss, semi-gloss and flats. Air-drying time is 15 min.

Black Oxide Process for Steel

The *Mitchell-Bradford Chemical Co.*, 2446 Main St., Stratford, Conn., has announced a new black oxide process for iron and steel known as Black Magic (Type A).

A one bath-one salt process, operating at a temperature of 290 F, the process is said to require only 6½ lb. of Black Magic salts per gal of blackening solution. This low concentration, plus low operating temperature, is said to contribute to the solution's high fluidity and thus minimize loss from drag-out of solution to the work.

Additional advantages claimed for the process are:

1. Provides high corrosion resistance.
2. Cuts down the blackening time cycle and also blackens heat treated or hardened work easily.
3. Self rectifying and will rectify build-up of colloidal red iron oxides in the bath and other contaminants which might inadvertently be introduced into the solution.

Substitute Finishes for Chromium

Parts which are normally chromium-plated can now be coated with a special synthetic enamel that produces a finish closely resembling chromium, according to the manufacturer, *Maas & Waldstein Co.*, Newark, N. J. The new finish—latest member in the line of Britelum coatings—was developed as an effective answer to the shortage of chromium for electroplating purposes. Applied directly over zinc or steel by spraying, the coating can be air-dried or baked.

A solution to the unavailability of copper, brass and bronze for plating purposes has been found through the use of special coatings also developed by Maas & Wald

53 BLAST FURNACES LINED WITH NATIONAL CARBON, TRADE-MARK HAVE AVERAGED 1,000,000 TONS EACH

— *and still going strong!*

National Carbon Company has now equipped 53 furnaces with carbon-block linings. 27 of these linings have produced over 1,000,000 tons of iron apiece at this writing. 10 of these linings have produced 1,500,000 tons. One lining has topped 1,900,000 tons. All linings are still going strong. We can think of no stronger proof of the value of "National" carbon for lining blast furnaces.

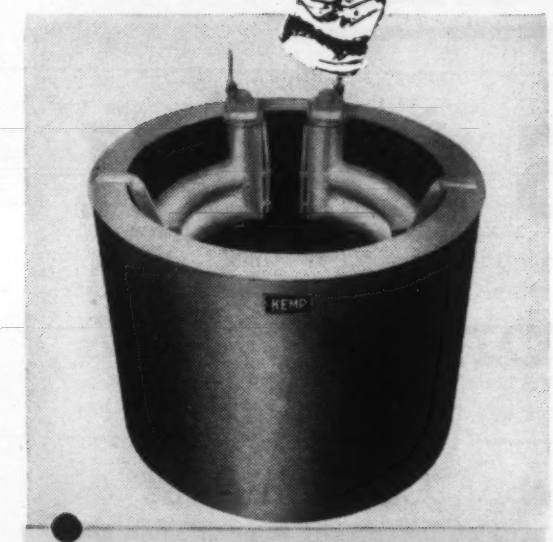
The term "National" is a registered trade-mark of
NATIONAL CARBON COMPANY
a Division of
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
In Canada: National Carbon Limited, Toronto 4

OTHER NATIONAL CARBON PRODUCTS

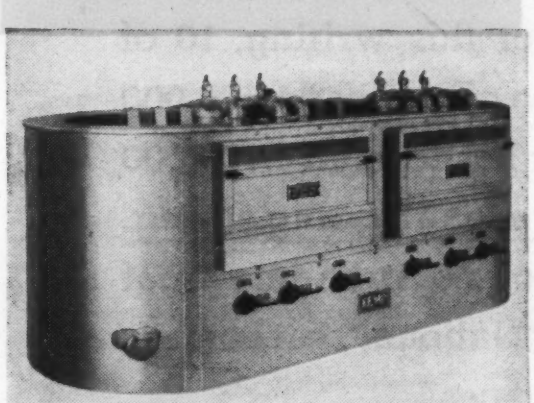
BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS

Actual reports show:

KEMP *Cuts Melting Costs*



Above is a 44" pot with 10,000 lb. capacity. Casting rate: two tons per hour. Estimated fuel savings of up to 40%.



Many newspapers report actual fuel savings of from 50% to 60% on fuel with 10-ton capacity melting pot shown above.

Kemp Gas-Fired Immersion Melting Pots Save up to 40% on Fuel Alone

Here's why you should replace conventional melting equipment with modern, efficient Kemp Immersion Pots. Actual reports show proof that Kemp Immersion Heating cuts fuel bills up to 40% and more. Now you can melt soft metals, lead, pewter, tin, or salt with maximum thermal efficiency and get double the rate of heat recovery.

POSITIVE HEAT CONTROL

Kemp Immersion Melting Pots have no brickwork to steal heat, no external combustion chamber, no carbon monoxide, no temperature overrun. You get high melting rates, reduced dross formation, speed of temperature recovery after adding cold materials . . . *PLUS* an estimated fuel saving of up to 40%.

FOOLPROOF OPERATION

Each installation includes the Kemp Industrial Carburetor to assure complete combustion, lower installation cost. Tell us your heating or melting requirements. We can help you make your unit more profitable.

KEMP OF BALTIMORE *IMMERSION MELTING POTS*

Write for Bulletin for technical information.
Address: C. M. KEMP MFG. CO.
405 E. Oliver St., Baltimore 2, Md.

CARBURETORS • BURNERS • FIRE CHECKS • ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS • METAL MELTING UNITS • SINGEING EQUIPMENT • SPECIAL EQUIPMENT

New Materials and Equipment

stein. Known as Platelustre, the new finishes are said to closely simulate the appearance of copper, brass and bronze when applied over zinc, steel or zinc-plated steel, and have withstood 800 hr of salt spray and weatherometer tests.

Non-Seize Thread Compound

Seizure of pipe, bolt and stud threads and gasket faces has presented an obstinate problem which has been solved through the development of a new metallic compound by *Armite Laboratories,* 6663 Broad Street, Los Angeles 1.

Combining the advantages of a lubricant and sealer, Led-Plate is said to have effec-

This new anti-seize compound combines the advantage of a lubricant and sealer.

tive results when used in temperatures from –350 F to 2900 F and higher.

Metallic elements, of which 70% is powdered lead, are held in suspension in hydrocarbons, and the materials will not dry out, according to the manufacturer. This advantage insures later disassembly against seizure.

The compound can be used for steam, gas, water, air, oil, ammonia and various chemical connections.

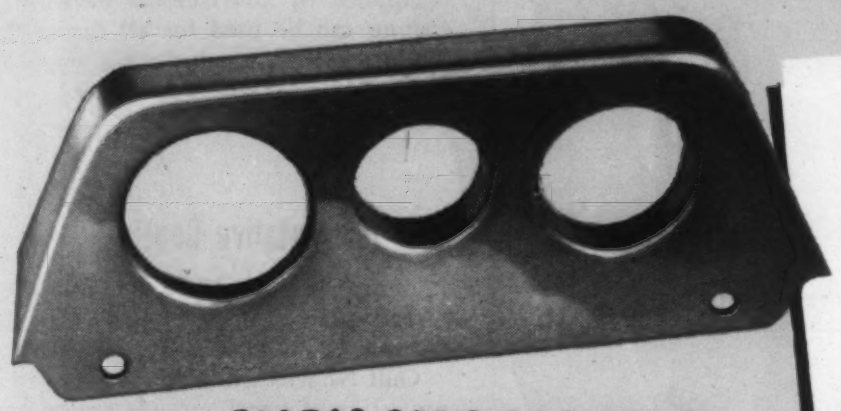
High Temperature Paint

Capable of withstanding temperatures up to 1900 F, the new series of high temperature paints, Fire-Gard, developed by *Fire-Gard, Inc.,* 1424 K St., N. W., Washington 5, D. C., is claimed to be applicable to all types of wood or metal surfaces.

Said to form a bright finish that is resistant to high temperatures, moisture, corrosion, mild acids and mild alkalies and oxidation or fumes encountered in industrial plants, the paints are available in

WAX LUBRICANTS !

Can greatly improve lubrication on even the most difficult metal forming and cutting jobs...Try them!



JOHNSON'S WAX LUBRICANTS

offer new metal working possibilities for ferrous and non-ferrous metals

Wax has proved its ability to do many metal lubricating jobs conventional lubricants cannot do.

Wax Lubricants have so improved lubrication during deep drawing, cold heading, tapping and cutting operations, especially on the difficult metals where oils become fugitive, that galling, tearing, die wear, welding of metal to tools, etc., were virtually eliminated. Wax Lubricants are clean, easily degreased and adaptable to any type of application. They will resist temperatures up to 550° F.

JOHNSON'S WAX LUBRICANTS

- **Permit multiple draws with one application**
- **Increase time interval between tool repair**
- **Increase die life**
- **Decrease rejected and damaged pieces**
- **Provide lubrication under extreme heat**
- **Protect parts and tools against corrosion**

Write for details concerning the use of Johnson's Wax Lubricants for your specific jobs. Give them a production test.

DRAWING STAINLESS STEEL

Production runs on thousands of pieces of No. 405 stainless drawn to the shape shown at the left proved that wax as the lubricant permitted drawing the metal far beyond its theoretical capacity and eliminated tool wear to such an extent that it could not be measured by micrometer.

COLD HEADING STAINLESS STEEL

Wax, used as the lubricant on stainless steel wire before it entered the cold heading machine, permitted far better fill-in of shoulders during the upsetting operation. Tests on waxed stainless wire offer evidence that copper flashing for lubrication purposes is unnecessary.

SHOE BENDING ALLOY TUBE

Wax used as the lubricant in the shoe bending of hard alloy tube reduced the required bending pressure by one-half, and eliminated the loss due to crimping and buckling.

LUBRICATING SELF-TAPPING SCREWS

A special wax blend adopted by screw manufacturers for lubricating self-tapping screws provided as much as 50% torque reduction with the improved lubrication.

S. C. JOHNSON & SON, INC.

Industrial Products Department MM6, Racine, Wis.

UNITCAST PRESSES

. . REDUCE FINISHING TIME—
. . GIVE MINIMUM TOLERANCE LIMITS!

Shown above are three presses ranging from 250 to 600 ton capacities, another important part of Unitcast's facilities that add quality to the product.

- **Do your castings assemble freely and within tolerance limits?**
- **Do your castings fit machining fixtures properly, consistently?**
- **Are your finish allowances held to a minimum?**

INTERCHANGEABILITY has long been recognized as the forerunner of mass production. Unitcast daily production is held to the specified dimensional tolerances, assuring you this very important advantage.

UNITCAST ENGINEERS CONTINUE TO BE AT YOUR SERVICE

UNITCAST
Corporation
QUALITY STEEL CASTINGS

Give us a chance to offer a "cast steel" answer for your parts problem. Our suggestions while your product is in the design stage will pay continuous dividends. Write or call today. Unitcast Corporation, Steel Casting Division, Toledo 9, Ohio. *In Canada:* Canadian-Unitcast Steel, Ltd., Sherbrooke, Quebec.

UNITCASTINGS ARE FOUNDRY ENGINEERED

New Materials and Equipment

aluminum and most colors, including black and white.

Applied by conventional methods, the coating can be used for all surfaces formerly regarded as unpaintable due to deterioration by high temperature or other corrosive influences.

Rust Preventative Coating

A new addition to its line of No-Rust compounds has been announced by *Gulf Oil Corp.*, 722 Gulf Bldg., Pittsburgh 30.

Gulf No-Rust No. 6 is recommended for protection of metal surfaces against corrosion in either indoor or outdoor exposure. A rust preventative of the thin film type, it is said to provide approximate surface coverage of 390 sq. ft. per gal.

Outstanding properties claimed for the compound are:

1. Will not settle or separate in storage.
2. Good adhesion.
3. Will not crack, chip, scale at temperatures down to 0 F, nor will it flow at temperatures as high as 190 F.

Depositing a coating not exceeding eight thousandths of an in. in thickness by dipping at a temperature of 70 F, the preventative is suitable for application by brushing, spraying or dipping and is readily removed with stoddard solvent or kerosene.

Plating Substitute

New protective coatings, applied over Iridite and similar metal finishing processes, produce an attractive, durable finish similar to chromium plating without the use of copper, nickel or chromium, according to the manufacturer, *Strathmore Products, Inc.*, 1970 W. Fayette St., Syracuse 4, N. Y.

Two types are now available: Baquik Clear Coating X2534, which is a baking type (range 225 F for 1 hr to 300 F for 15 min) and Metalbond Clear Coating SL-300, which is an air-drying type.

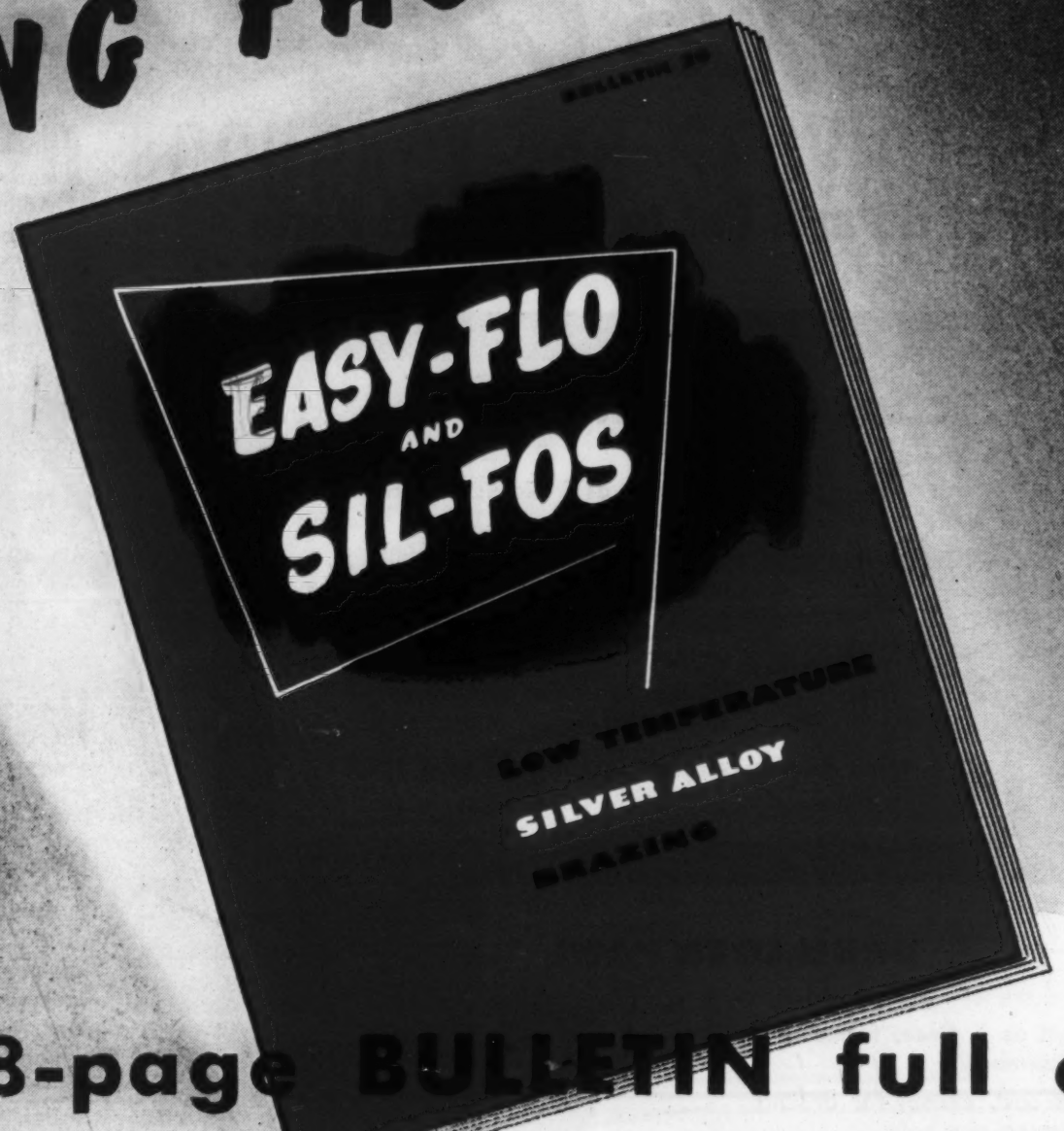
Both can be sprayed or dipped, and are said to contain a large percentage of solids, retain color and possess high resistance to impact and abrasion.

Anti-Corrosive Coatings

Six coal-tar base anti-corrosive coatings for the protection of metals, wood, masonry and insulation have been developed by *Continental Coatings Corp.*, 304 W. 44th St., New York 19.

These coatings are said to form a tough,

GOING FAST!



this 28-page BULLETIN full of useful metal joining information

ALWAYS USE HANDY FLUX with EASY-FLO and SIL-FOS . . .

to get the full benefit of the low flow points of these alloys which go from 1135°F to 1300°F. At 1100°F. HANDY FLUX is fully liquid and active and dissolves practically all refractory oxides, chrome oxide included. In addition, HANDY FLUX has excellent cleaning properties and washes off readily in hot water after brazing. In convenient paste form, it is easy to brush on and stays put. For details write for Bulletin No. 9.

■ Requests for this new bulletin have been pouring in. And scores of letters have come in from design and production engineers praising the clear and complete way in which it presents the facts about low-temperature silver alloy brazing. Many of them say the information in the bulletin — particularly on joint design and on fast brazing production methods — has enabled them to speed up and improve some of their own metal joining work. Don't miss out—write for a free copy of Bulletin 20 today.

HANDY & HARMAN

HANDY & HARMAN · FOUNDED 1867 · QUALITY SERVICE

82 FULTON STREET NEW YORK 38, N. Y.

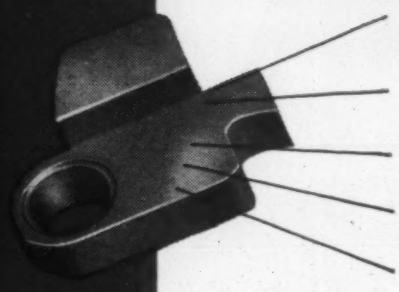
BRIDGEPORT, CONN. • CHICAGO, ILL. • LOS ANGELES, CAL. • PROVIDENCE, R. I. • TORONTO, CANADA • AGENTS IN PRINCIPAL CITIES

Microcast®

Slashes Cost

Assembly of 6 Parts Cut to 2 Integral Parts

CLUTCH STOP PAWL



Microcast as 1 piece; formerly 4 piece assembly.

Used as cast, except for drilling and reaming one hole.

Sound structure — dimensionally uniform.

Milling operation and assembly eliminated.

Microcasting reduced cost on this part 20%.

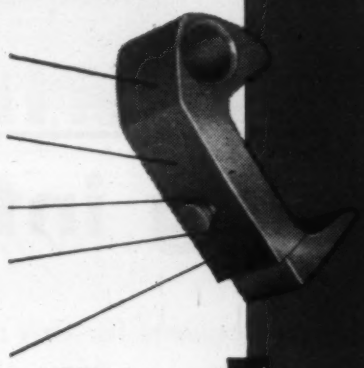
DRUM LOCK PAWL

Microcast as 1 piece; formerly 2 piece assembly.

Used as cast, except for drilling and reaming one hole.

Special form cutters, gages, jigs, etc. eliminated.

Milling operation and assembly eliminated.



Microcasting reduced cost on this part 75%.

MICROCAST TRADE MARK REG. U.S. PAT. OFF.

MICROCAST PRECISION CASTINGS PROCESS

MICROCAST offers design engineers many opportunities for product improvement of small components with substantial savings in cost. High melting point, non-machineable, non-forgeable alloys can be specified for economical quantity production, too. Write for complete information.

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th St., New York 16, New York
715 East 69th Place, Chicago 37, Illinois

FREE BOOKLET

Get your copy of this all-inclusive 16-page booklet on Microcastings. Write today!

MICROCAST

New Materials and Equipment

elastic film which resists the penetration of chemicals, fumes, moisture and heat.

Additional properties claimed for the coatings are:

1. Non-soluble in oil and completely waterproof.
2. Resistant to strong inorganic acids and strong alkali, ranging from sulfuric to caustic potash.
3. Protects against alcohol, formaldehyde, salt spray and a wide variety of organic acids and other chemicals.

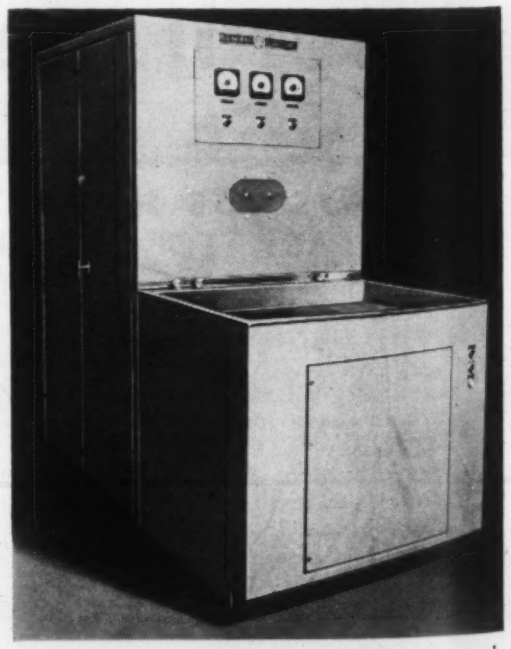
No primer is needed for these coatings. They are said to protect in direct ratio to film thickness and number of coats applied.

Heating, Heat Treatment

Induction Heater

An improved electronic type 20-kw induction heater, featuring a nonventilated, dustproof, NEMA Type 12 enclosure, has been announced by the Industrial Heating Div., *General Electric Co.*, Schenectady 5.

For use in high-speed annealing, brazing, hardening and soldering, the new heater is said to be designed so that only



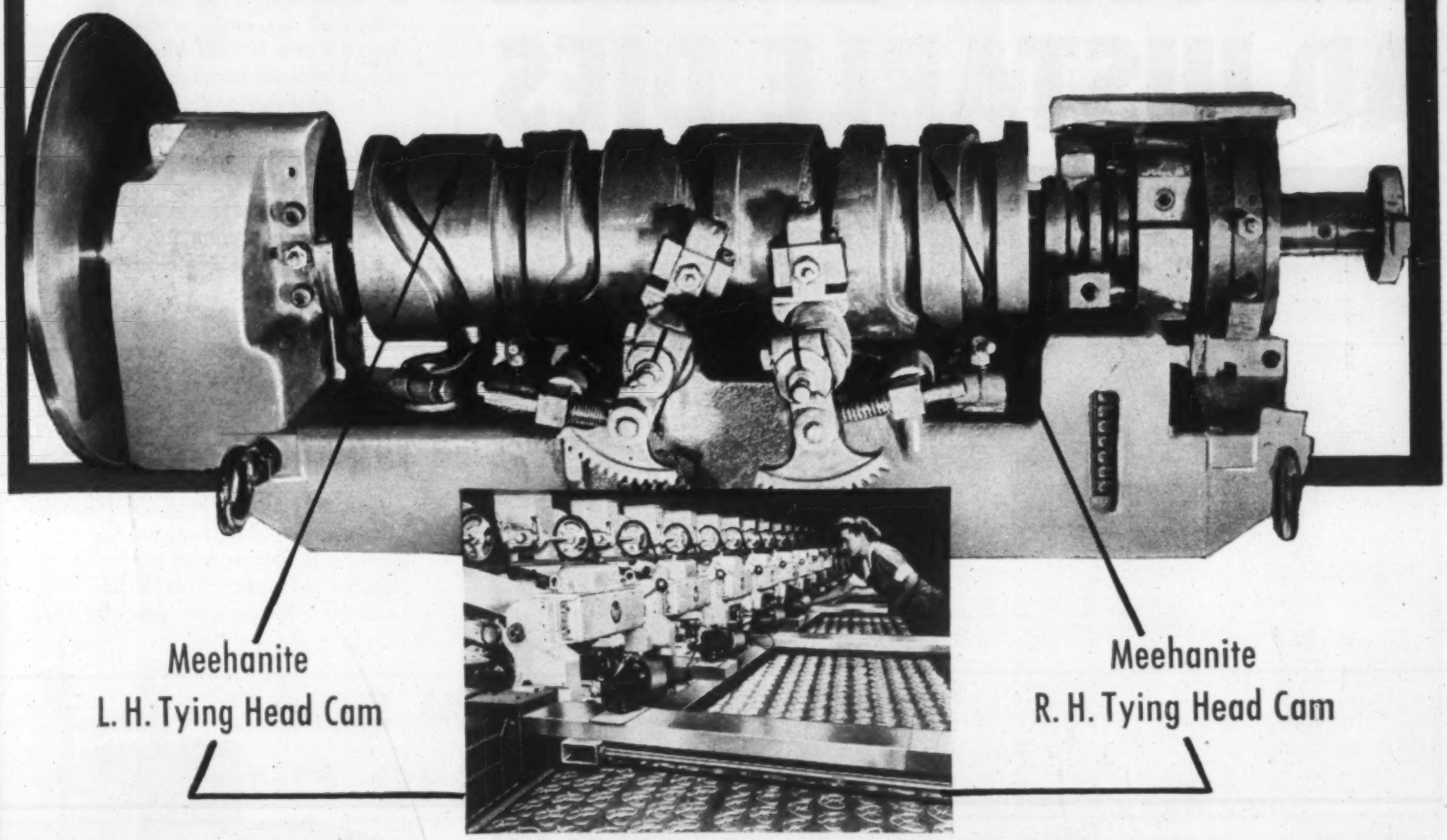
This induction heater weighs approximately 3600 lb and is available on 230-, 460- or 550-v, 3-phase, 60-cycle power supply.

the control and accessories required for a particular heating application need be purchased.

The totally-enclosed steel cabinet is equipped with felt-gasketed and bolted doors to protect the components from dirt, grit or oily vapors, thus reducing the need

The Wear Resistance of MEEHANITE Metal offers

PROLONGED ACCURACY and SERVICE LIFE



Meehanite
L. H. Tying Head Cam

Meehanite
R. H. Tying Head Cam

The accuracy of the mechanism of a machine reproducing the tying motions of human hands and fingers in the manufacture of pretzels is dependent in many ways upon the Meehanite cam illustrated. Manufactured by the American Machine & Foundry Company, New York, N. Y., the machine contains many unique design features built around the dependability and steady accurate performance of many parts governed by the Meehanite cam. The cam is built up from two Meehanite castings into which seven individual cam tracks are machined.

Freedom from after-machining distortion, plus the wear resistance and machinability of the Meehanite castings are important contributions to the equipment.

The better properties of Meehanite castings are achieved through established and scientific production controls and these extras in characteristics and quality can help improve your product and manufacturing efficiency.

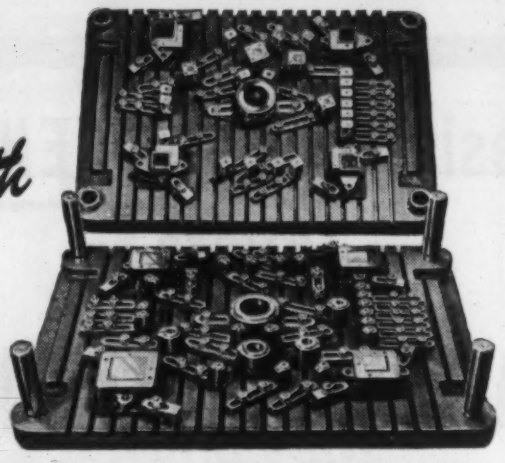
WHEN YOU NEED "EXTRAS" IN QUALITY OR PROPERTIES CONSULT ANY OF THE FOUNDRIES LISTED BELOW

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Canton, O.
Builders Iron Foundry	Providence, Rhode Island
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Lincoln Foundry Corp.	Los Angeles, California
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

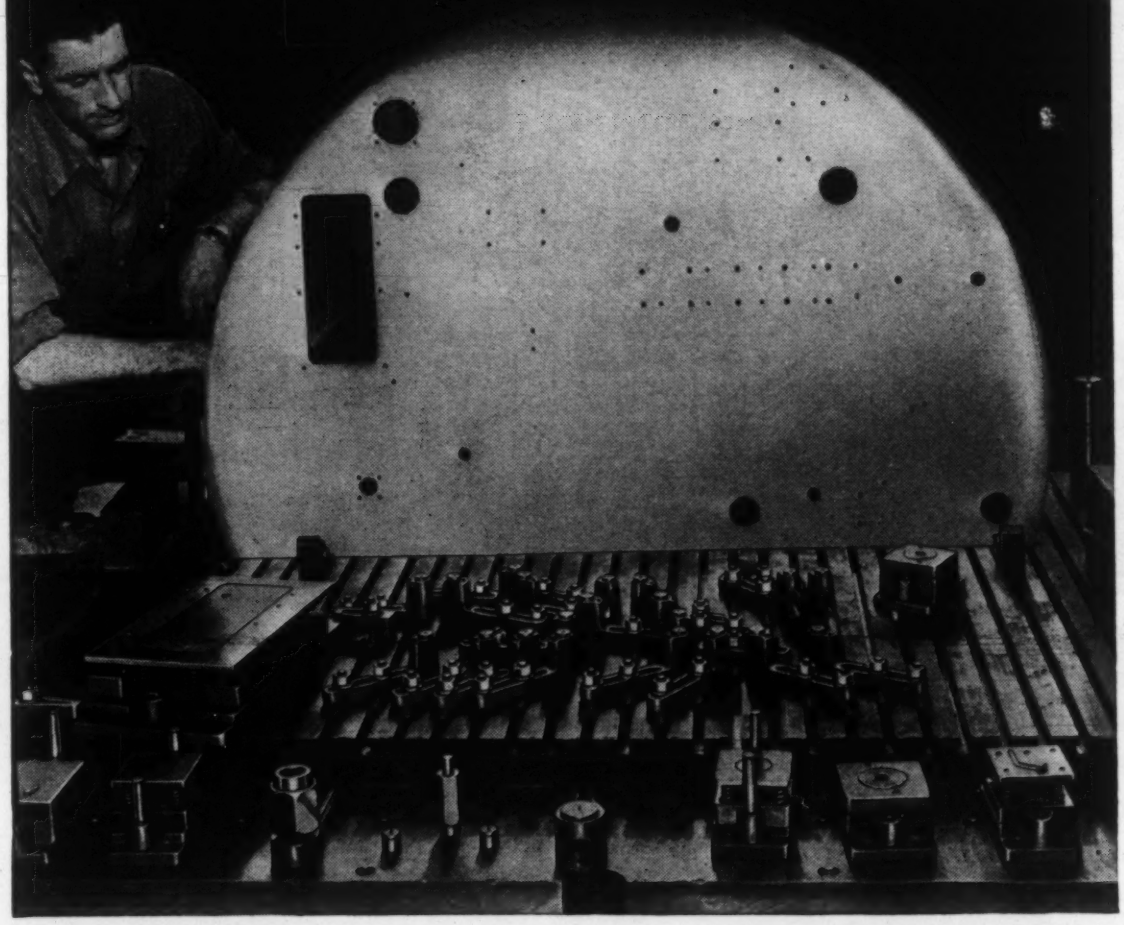
MEEHANITE® NEW ROCHELLE, N. Y.

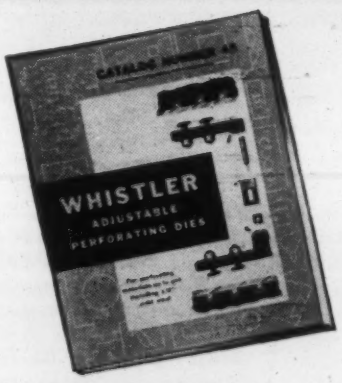
Get into Production in a few hours with



WHISTLER ADJUSTABLE DIES

Whistler Adjustable Perforating Dies are in use everywhere . . . working in both large and small presses.





There are plenty of other advantages in using Whistler Adjustable Dies. It makes sense to get the complete story. And it's easy to do. Write for your Whistler Catalog today.

Whistler perforating dies now offer a double-barreled advantage in getting into production faster. Standard sizes of round hole punches and dies... 1/32 to 3"... can be shipped promptly. Special shapes... squares, ovals, rectangles, group and notching dies, are quickly made to order.

Equally important, set-ups are simple... take only a short time. Same units can be rearranged or units added in setting up different jobs. Production is thus speeded while die costs are amortized through continued re-use.

No special tools are needed. All parts are interchangeable. The heavy duty series of punches and dies easily pierce materials up to 1/4" mild steel.

S. B. WHISTLER & SONS, INC.

756 MILITARY ROAD • BUFFALO 17, NEW YORK

New Materials and Equipment

for maintenance, and providing a minimum of "downtime."

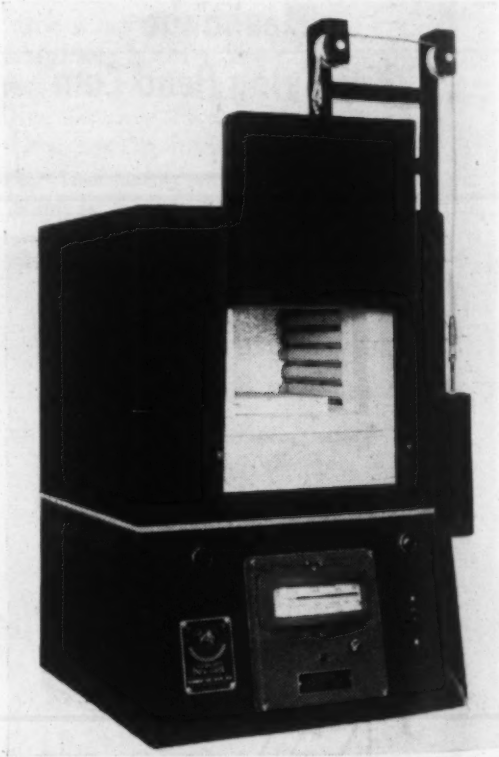
Suitable for long- or short-run production, the unit is available in two models—with or without variable power adjustment.

For short-run production of a wide variety of parts, the manufacturer recommends the Type HM-20L1 heater, while Type HM-20L2 is suggested for long-run, higher-production applications which do not have rapid cycling.

The heater is certified to meet FCC regulations.

Hardening and Tempering Furnace

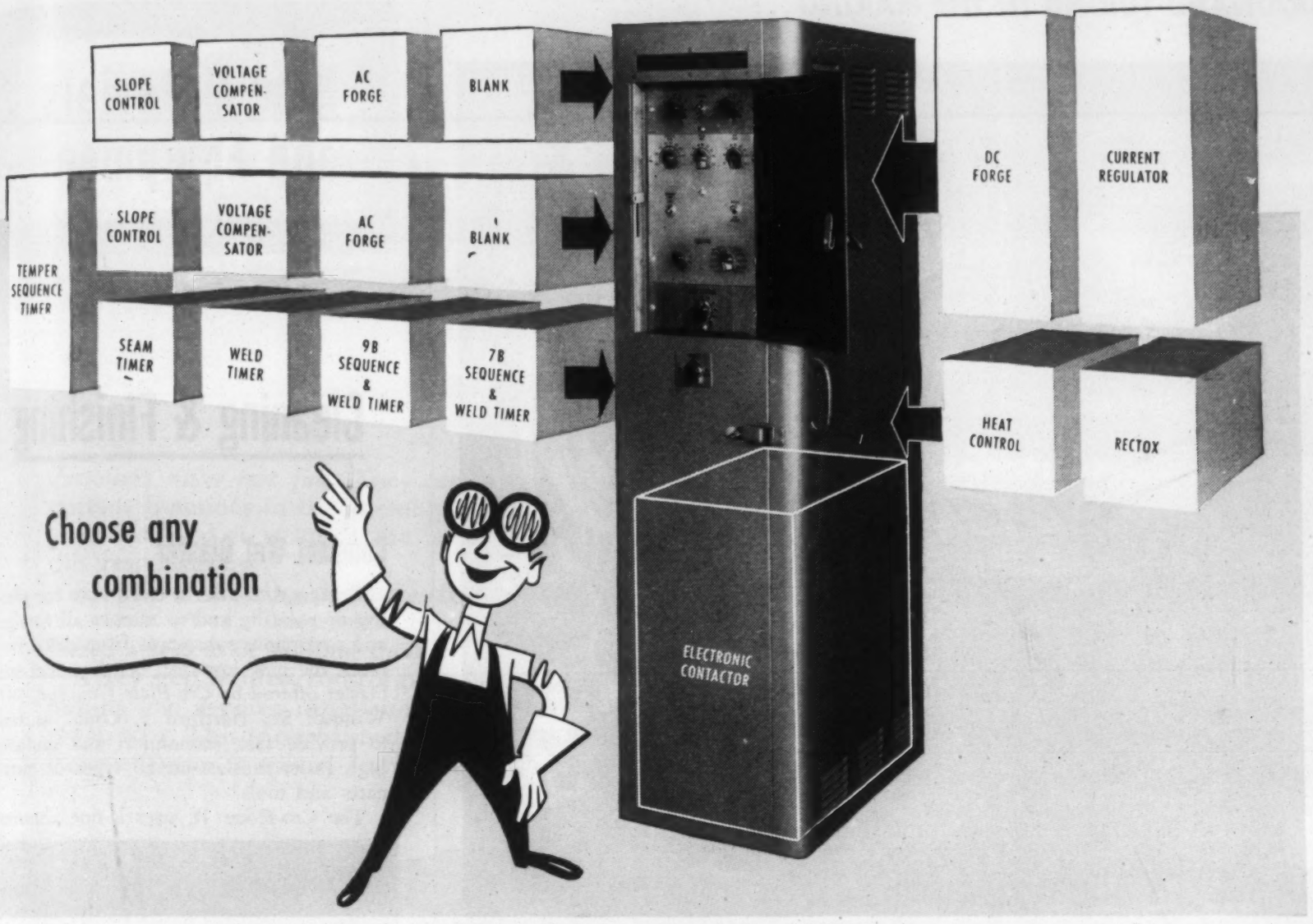
Currently offered by *K. H. Huppert Co.*, Chicago, the new Huppert No. 869 combination hardening and tempering furnace features a Huppert Infitrol and electronic controller designed to give the operator



This hardening and tempering furnace is available as a floor model or as a bench model.

automatic control of temperatures ranging from 300 F up to 2200 F.

Measuring 8 by 6 by 9 in. with maximum current consumption of 4 kw, the furnace is wired for 220-v single-phase operation. Designed with an easy-to-operate counterweighted door which rides in a wedge slide to seal the door in the closed position, the furnace is said to be sturdy in construction with heating elements made of nonscaling, nonflaking high temperature coiled alloy wire.



KEEP YOUR WELDING CONTROLS OUT OF MOTH BALLS

Interchange these components to match production changes

Now you can keep your resistance welding control "on the line", regardless of production changes. With a Westinghouse Welding Control you merely add or substitute the necessary control components.

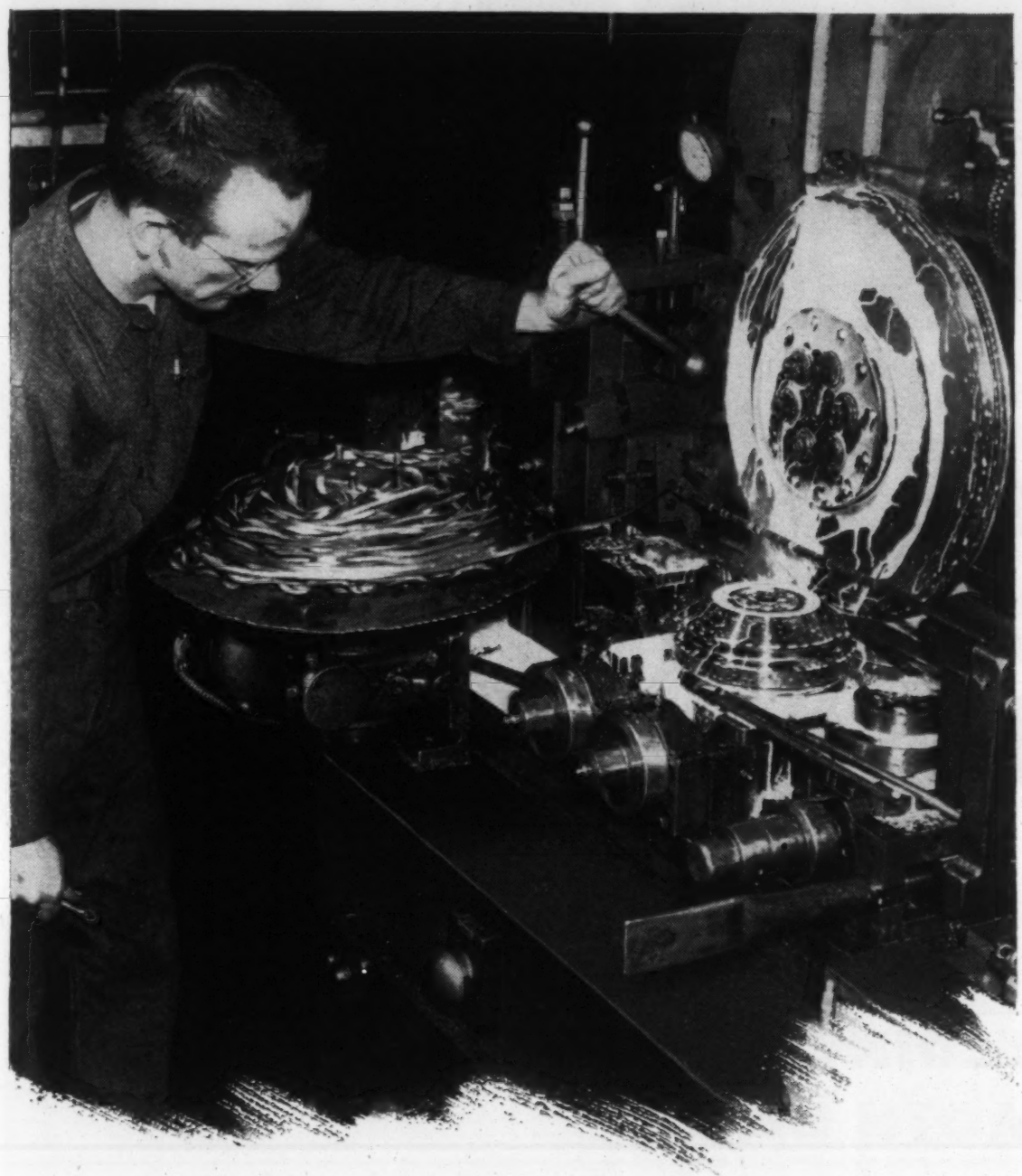
The Westinghouse Welding Control is built up of basic control components and auxiliary control units. Basic controls include the electronic contactor and sequence and weld timer, synchronous or nonsynchronous. Auxiliary controls include a wide range of functional units among which are: forge timer, slope control, voltage compensator and dual weld attachment. Combinations of the complete line of components can be assembled to meet the needs of practically all resistance welding techniques. All component units plug in to either a 600 or 1200-frame electronic contactor structure.

Each unit is self-contained and completely prewired at the factory. Mount the panel and insert the polarized plug—that's all it takes to make a complete change-over.

Many other advancements in control design such as the transformer-type flow switch, are built into this packaged control for resistance welding. Get the complete story from your Westinghouse representative or write for Booklet B-4309. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-27006

YOU CAN BE SURE.. IF IT'S
Westinghouse
RESISTANCE WELDING CONTROL

BRAINARD TUBING IN THE MAKING...



THE WELDING OPERATION involves a split electrode with current passing from one side to the other, heating the tube to welding temperature. The side pressure rolls then force the bond. Excess metal is peeled off, making a clean, neat tube. Busy as we are in times like these, this operation gets careful supervision at Brainard. We have complete control of every operation from ore to tube. That's why it will pay you to call on Brainard first when you have a job for electric welded mechanical tubing. Straight or fabricated. Sizes: ½" to 4"—.025 to 165.

Sales offices: Atlanta, New York, Cincinnati, Pittsburgh, Buffalo, Chicago, Philadelphia, Dearborn, Cleveland, Tonawanda, N.Y., Rochester, Indianapolis, Nashua, N.H. Sales representatives: Sharonsteel Products Co., Dearborn, Mich., Grand Rapids, Mich. and Farrell, Pa. Fred J. Reynolds, Davenport, Iowa. Brass & Copper Sales Co., St. Louis, Mo. and Kansas City, Kan. Julius Schulz, Dallas, Texas.

Brainard
SHARONSTEEL
STEEL COMPANY
WARREN, OHIO

New Materials and Equipment

Cleaning & Finishing

Compact Wet Blaster

Designed to offer a clean base for plating or painting and to remove all foreign and amorphous substances from metal surfaces, the new low-cost, bench model wet blaster offered by *Cro-Plate Co., Inc.*, 747 Windsor St., Hartford 5, Conn., is said to provide fast, economical and uniform high luster finishes on all types of metal parts and tools.

The Cro-Hone Jr. uses a fine abrasive

All that is needed for immediate operation of this wet blaster is a ⅜-in. air connection and a ½-in. water connection.

suspended in a water carrier which is forced against large or small metal parts by air pressure through a siphon jet gun. Operation is said to be simple. The metal part to be finished is inserted through the front window door and is held in one hand while the jet gun is operated in the other. Work is watched through the window in front of the cabinet.

Constructed of stainless steel, the unit has no moving parts or circulating pumps; thus, maintenance requirements are low. Also, the small compact construction, in addition to low abrasion replacement cost, is said to ideally suit the blaster to use in tool and die shops, electroplating shops,

"Putting the Pressure" on SPEED NUTS

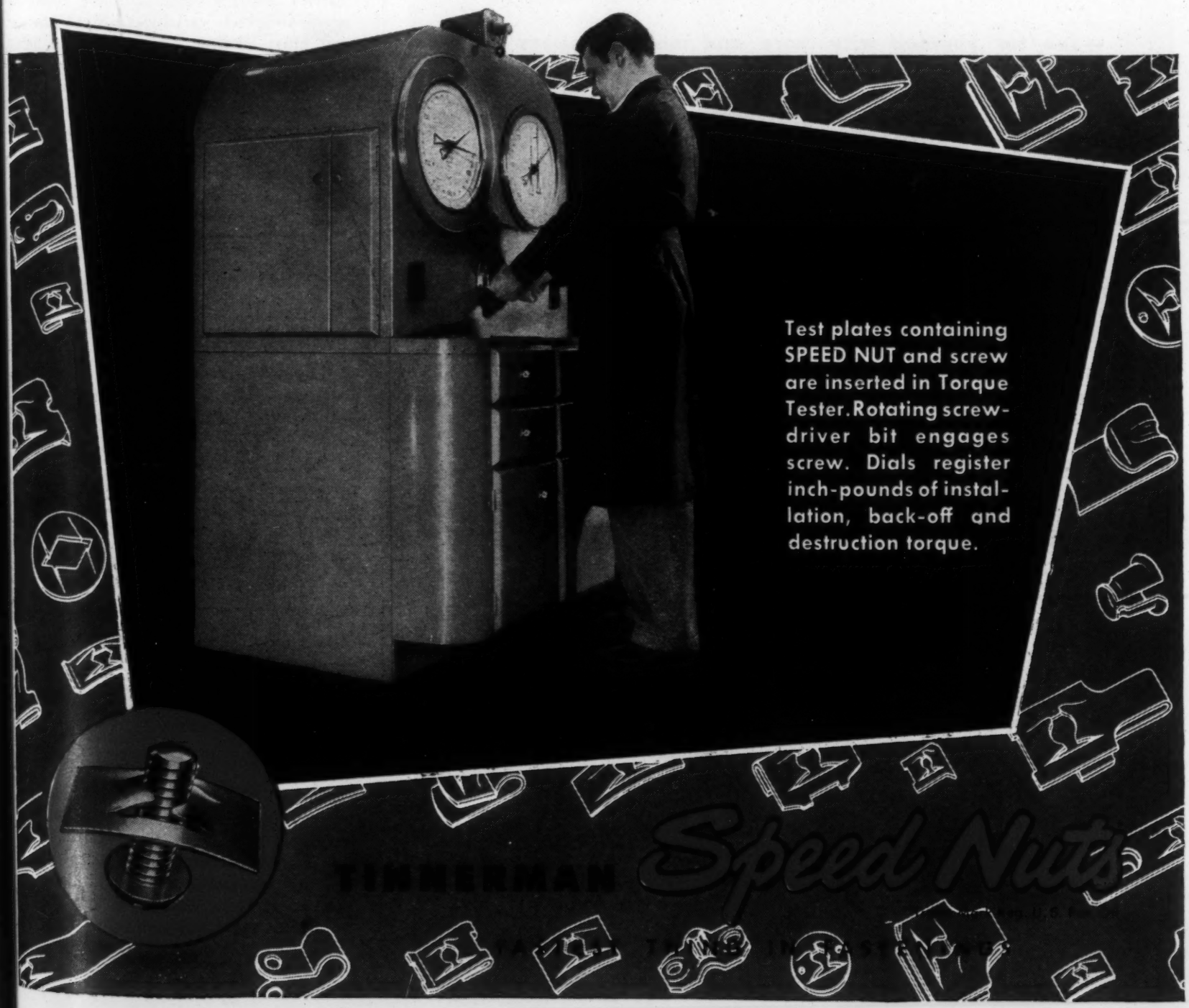
. . . to assure highest quality fasteners for your products

Fasteners must not fail. They are assigned important functions in the assembly of all types of products. And it is up to the fasteners to meet this responsibility.

By way of assuring the successful performance of SPEED NUTS, Tinnerman Products has perfected a system of vigilant quality control.

A key step in these control procedures is determining the average installation torque for each SPEED NUT. This is established by the Mechanized Torque Tester, a special "torture rack" designed by Tinnerman engineers. The torque values set up by this tester assure the extreme holding power and great vibration resistance of SPEED NUTS.

This is only part of the Tinnerman quality control program. The entire procedure has been described in a new illustrated booklet, "The Story of Quality"—write for your copy. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.



Test plates containing SPEED NUT and screw are inserted in Torque Tester. Rotating screwdriver bit engages screw. Dials register inch-pounds of installation, back-off and destruction torque.

COMPARE

your present ALUMINUM FINISHING PROCESS with these advantages of IRIDITE® Al-Coat

—see for yourself why more and more finishers of aluminum products are specifying Iridite Al-Coat for any wrought, cast or buffed aluminum part.

1. IN PROCESSING

Faster—Just one simple dip, 10 seconds or only two minutes, depending upon your finishing specifications. No sealing dip, no special drying.

Simpler—Non-electrolytic, no heating or exhaust units, operates at room temperature. No special precleaning baths required.

2. IN APPEARANCE

Clear—Protects metal without changing its original appearance.

Colored—Heavier, iridescent yellow film provides greater protection.

3. IN PERFORMANCE

Corrosion Resistance—Up to 1,000 hours salt spray on wrought stock, 250 hours on castings. Approved under government specifications.

Abrasion Resistance—Will not flake or peel from buffing, bending or scraping.

Paint Base—Blocks underfilm corrosion; grips paint, holds it firmly.

Welding—Finished surface can be spot welded, coating actually aids shielded arc welding.

Conductivity—Offers low surface resistance to electrical current.

4. IN COST

Comparative figures show that Iridite Al-Coat saves as much as 50% over other aluminum finishing processes. *Let us prove this to you.*

Write today for FREE SAMPLES of Iridite Al-Coat. Or, send samples of your product for test processing.

Iridite is approved under government specifications.

ALLIED RESEARCH PRODUCTS
INCORPORATED
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REPRESENTATIVES IN PRINCIPAL INDUSTRIAL CITIES; West Coast: L. H. BUTCHER COMPANY
Manufacturers of Iridite Finishes
for Corrosion Resistance and Paint Systems for Non-Ferrous Metals; ARP Plating Chemicals

New Materials and Equipment

methods engineering set-ups and auto repair shops.

Coating Machine

A new machine for the application of rust preventative coating has been announced by *Cincinnati Cleaning and Finishing Machinery Co.*, Ironton, Ohio.

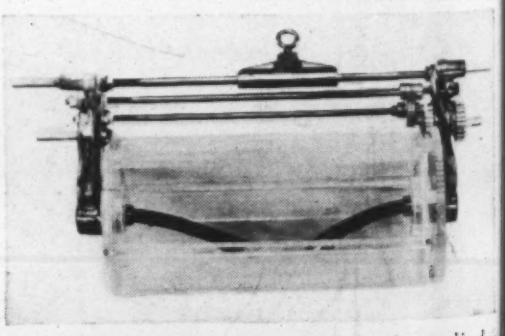
Especially designed for the application of government specification No. AXS-673 corrosion preventative compound, the machine is said to spray the compound on parts and then to dry the coating before discharging the parts.

In operation, a wire mesh conveyor belt carries the parts through the following steps at speeds variable from 1½ to 3 ft per min: loading, oil spray, drain, infra-red drying, cooling and unloading.

Among other features, the manufacturer lists: explosion-proof switches, motors and wiring, spark-proof pumps, supply tank for rust preventative, belt cleaning tank on return leg of conveyor, adjustable infra-red drying lamp bank, automatic carbon dioxide fire protection, and spark-proof exhaust fan and duct system.

Polishing Tallows

Development of a new line of polishing tallows available in three types, 5B41, 5B42 and 5B47, has been announced by



Here is a Mercil type Plexiglas cylinder with hanger equipment and flexible dangler contacts.

Hanson-Van Winkle-Munning Co., Matawan, N. J.

Tallow 5B41 is a low cost material which is said to have excellent lubricating qualities, a medium high melting point and good saponification characteristics.

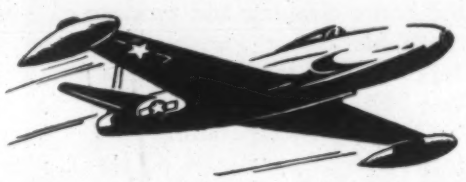
More economical, and of a higher grade, Tallow 5B42 is claimed to have higher lubrication and saponification properties than 5B41 and to be exceptionally easy to clean.

The third type, 5B47, is highly saponi-

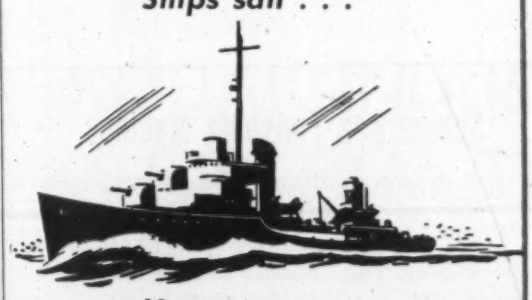
Plastics Check list

A useful summary of the current situation... for designers or engineers who are planning to "do it with plastics"

Planes fly . . .



Ships sail . . .



Motors run . . .

. . . with *plastics* serving in vital spots. Plastics serve the nation's defense in countless, all-important ways. USE THEM WISELY!

As the pressures for more production increase . . . as the shortages of materials, labor, and power grow more critical . . . someone in your organization is almost sure to ask you, *"Why not use plastics?"* It's a good suggestion. In many instances plastics have replaced other materials because of their superior advantages for certain applications. But whatever *your* company manufactures, whatever the specific materials problems *you* might hope to solve with plastics, the following facts should be kept in mind:

✓ **Today plastics are essential materials.**—Because of their versatility, their adaptability to volume production, their economy of time, labor, and power—plastics are basic raw materials in their own right—of vital importance to defense industry.

✓ **Many plastics are already in short supply.** Monsanto and other materials producers are expanding output as rapidly as the basic chemicals become available, but essential applications will probably continue to take most of the plastics supply.

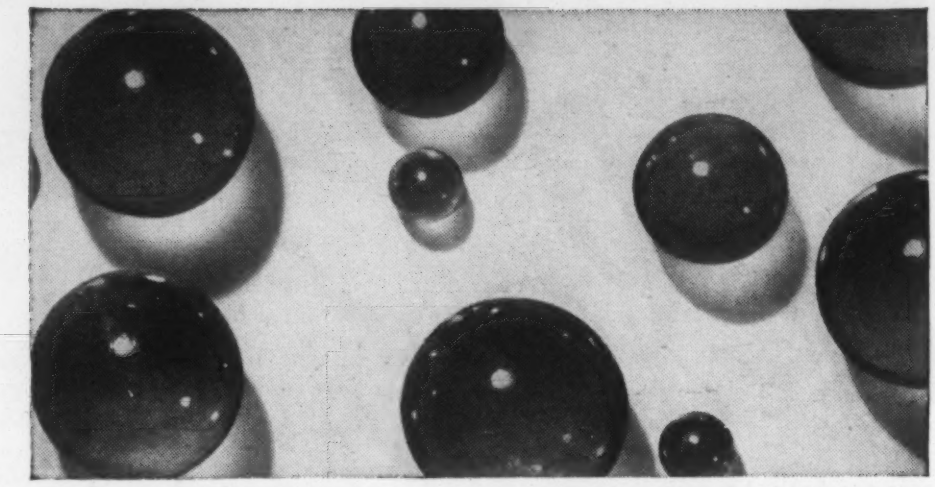
✓ **Plastics must be used correctly.** Like any other material, they have their limitations. And what is a sound application for one plastic may be entirely impractical for another.

We suggest that you send your materials engineering questions about plastics to the Monsanto Plastics Technical Council. This Council, composed of technical experts on every material in the industry's biggest family of plastics, will study your design and/or materials problems and make recommendations. Or, if you prefer, get in touch with the nearest Monsanto sales office.

MONSANTO CHEMICAL COMPANY
Plastics Division, Springfield 2, Mass.

The big MONSANTO *family of plastics*

SERVING INDUSTRY . . . WHICH SERVES MANKIND



Now PRECISION BALLS *of Synthetic Sapphire*

Now . . . the wear, corrosion, and heat resistance of synthetic sapphire in balls polished to within 20 micro-inches of sphericity.

THESE unicrystalline spheres resist corrosion or erosion by many acids and alkalis . . . possess a higher dielectric strength than glass or mica . . . have a low coefficient of friction and superior hardness. In many applications, they need not be lubricated.

LINDE synthetic sapphire balls are available in 1mm, 1/16 inch, 1/8 inch, and 1/4 inch sizes. Three surface finishes are available: super-finished, semi-finished, and rough-ground blanks.

CALL or WRITE any LINDE office for information on these balls, or the other forms of LINDE synthetic sapphire.

PROPERTIES

Composition	Al_2O_3
Coefficient of Friction (Steel pivot on sapphire ring)	0.140
Hardness (Knoop)	1525—2,000
Modulus of Elasticity in Flexure	50—56 x 10^6 psi
Dielectric Constant	7.5—10
Modulus of Rigidity	21.5—27.5 x 10^6 psi
Thermal Coefficient of Expansion up to 50°C (per °C x 10^{-6})	5.0—6.7
Chemical Resistance	Unaffected by acids, dilute alkali.

LINDE AIR PRODUCTS COMPANY

A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

30 E. 42nd St., New York 17, N. Y. Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of Union Carbide and Carbon Corporation.

New Materials and Equipment

fiable and gives good lubrication. It is most economical in cost.

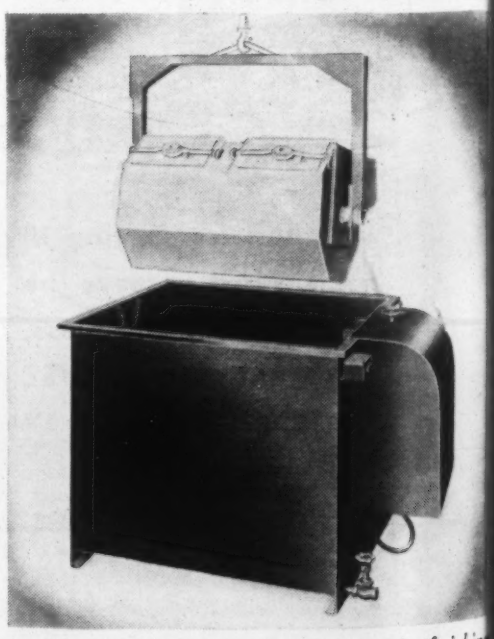
Another new product being offered by Hanson-Van Winkle-Munning Co. is a plexiglas plating cylinder said to be suitable for either cyanide or acid solution. The cylinders can be carried through the entire cleaning, pickling and plating cycle, and where cyanide solution is involved, are equipped with 90-tooth cast iron gears with both hangers of cast iron. Cast iron hangers are recommended for cadmium, cyanide copper, BBZ-200 zinc or any other alkaline or cyanide bath.

Where the cylinder is used in an acid solution such as nickel, or carried through the entire cleaning and pickling cycle, 90-tooth Merlon or Plexiglas gears will be supplied and the hanger arms will be of cast iron, rubber covered.

Only high temperature Plexiglas, satisfactory for temperatures of 185 F, is used and the cylinder is guaranteed to stand up under such conditions.

Submerged Finishing Machine

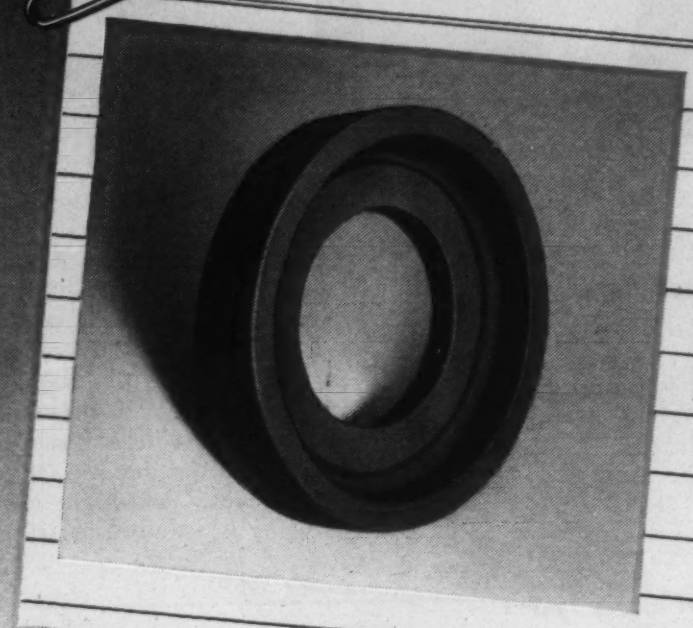
A new addition to the Almco Supersheen line of finishing equipment, now being offered by the Almco Div. of *Queen Stove Works, Inc.*, Albert Lea, Minn., the submerged unit is designed to allow manufacturers to do barrel finishing who could not before employ this cost-saving, labor-saving manner of finishing parts. Said to



This model SB-1 submerged finishing machine is for use alone or "in-line" for multiple operation processing.

be particularly useful in the processing of heavy parts and large soft metal parts, the unit's cushioning effect, which results from the complete immersion of the barrel

What's the *right* X-Ray film?



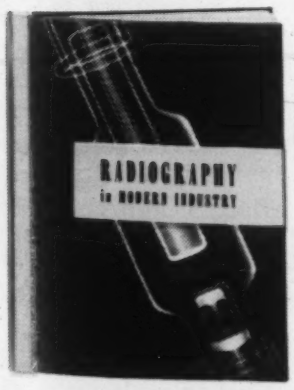
Product:
8-inch gear blank
Material:
1¼" bronze, ½" web
Equipment:
250 kv x-ray machine

ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE M

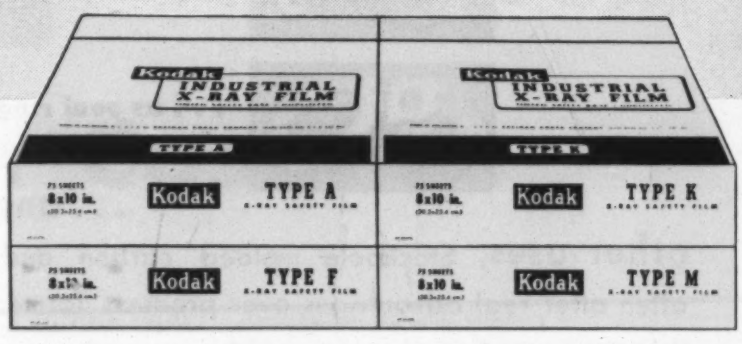
This gear blank was headed for a precision job. Even tiny imperfections were "out." To rule out such irregularities called for a radiograph of the best possible radiographic quality.

So the radiographer selected Kodak Industrial X-ray Film, Type M. This has extra-fine grain and high contrast. It provides the highest radiographic sensitivity available for critical inspection of all metal alloys.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price $3.



A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. These provide the means to check castings and welds efficiently and thus extend the use of both processes.

Type A—has high contrast with time-saving speed for study of light alloys at low voltage and for examining heavy parts at 1,000 kv. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, under direct exposure or with lead-foil screens. It has extra-fine grain and, though speed is less than in Type A, it is adequate for light alloys at average kilovoltage and for much million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N.Y.

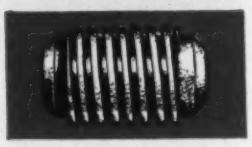
Radiography...

another important function of photography

Kodak
TRADE-MARK

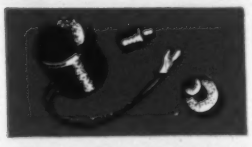
Having a hard time getting "CRITICAL" metals?

. . . as power and mercury arc rectifier tube anodes



. . . as bearings

. . . as molds and dies of many types



. . . as contacts for a wide variety of uses

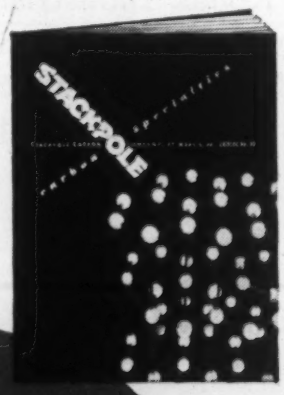
. . . as seal rings

. . . and in numerous other uses, Stackpole molded carbon and graphite materials often offer real advantages over products formed of "critical" metals that, at best, are scarce or which, at worst, are simply unobtainable.

Chemically, electrically and mechanically, carbon and graphite offer a maximum of the desirable properties of both metallic and non-metallic materials and a minimum of their disadvantages. Problems of friction, temperature, arcing, corrosion—and many others—can frequently be solved better, and at less cost.

Write for this big carbon-graphite booklet!

Stackpole Catalog 40 describes dozens of standard items and includes helpful data on the selection of carbon-graphite products.



Stackpole Carbon Company, *St. Marys, Pa.*

STACKPOLE

"EVERYTHING in CARBON BUT DIAMONDS"

New Materials and Equipment

lessens the impact between large parts to such an extent that nicking and scratching are said to be kept to a minimum.

Another adaption of the unit is in the processing of smaller parts requiring the utmost in color and micro-inch finish. The perforated steel drum revolves in an open tank of liquid. The drum is loaded with work parts and the abrasive chips or metal shapes. Various liquid compounds are used in the tank, depending on whether the operator is to burnish, polish, clean, descale or rustproof.

Change Tank Mixer

A new change tank mixer, #131-AB, designed for thinning-down, shading and tinting various size batches of materials from 80 to 250 gal, has been announced

Two-speed motors and tank covers are optional features of this change tank mixer.

by *Charles Ross & Son Co.*, Brooklyn, N. Y.

Simply, yet sturdily constructed, the low cost unit features an explosion proof motor in 3- or 5-hp size which is directly connected to the stirrer shaft, making a complete unit.

This arrangement is designed to operate in a minimum of headroom and is said to eliminate chain drives and gears.

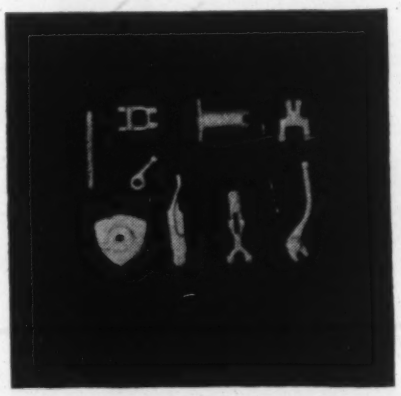
Accumet Precision Castings

for all industrial uses

With Accumet Precision Castings, Crucible has developed a process of producing precision investment castings in intricate designs with the smooth, satiny finish and closely-held dimensions characteristic of "lost wax" castings. Casting tolerances start at plus or minus 0.005" although under certain circumstances closer tolerances can be held. This relatively new metal forming process solves many difficult problems in design, tooling and production of metal components.

fuel injectors from precision castings

Fuel injectors and carburetors for aircraft are mechanisms containing a variety of peculiarly shaped component parts. The usual procedure is to use hardenable, chrome stainless steels, Types 416 and 440F, which are most adaptable to easy machining. However, to save costs in machining from bars, stocks and forgings, Crucible applied Accumet Precision Castings. The close size control and good surface finish of the castings eliminate many costly machining operations — saving manpower, machine time and tooling expense.



more information available on castings

Long a leader in the development of precision investment castings, Crucible offers you the services of an alert metallurgical staff to help you profitably apply these specialty steels to your operation. Write us for more detailed information. CRUCIBLE STEEL COMPANY OF AMERICA, General Sales and Operating Offices, Oliver Building, P. O. Box 88, Pittsburgh 30, Pennsylvania.

CRUCIBLE first name in special purpose steels

51 years of Fine *steelmaking*

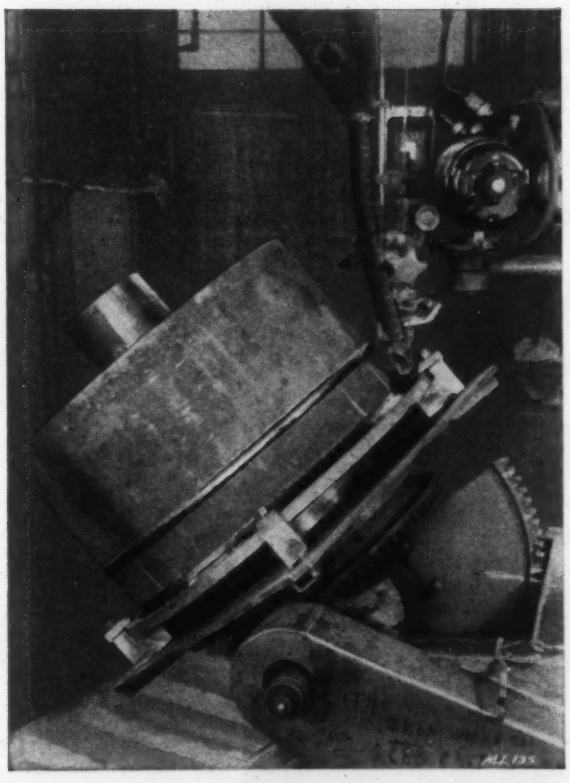
PRECISION CASTINGS

REX HIGH SPEED • TOOL • STAINLESS • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

FOR QUALITY WELDMENTS

call in

VAN DORN"



• You can be sure of outstanding quality if your weldments are produced by Van Dorn. For Van Dorn has complete fabricating facilities . . . experienced design engineers . . . specially trained workmen . . . 77 years' experience in metal working.

Consult us about your requirements—no obligation, of course. The Van Dorn Iron Works Co., 2685 East 79th St., Cleveland 4, Ohio.

Send For

FREE WELDMENT BOOK

Profusely illustrated; describes the many advantages of Weldments, and Van Dorn's extensive facilities.

New Materials and Equipment

Welding & Joining

Rubber Cement

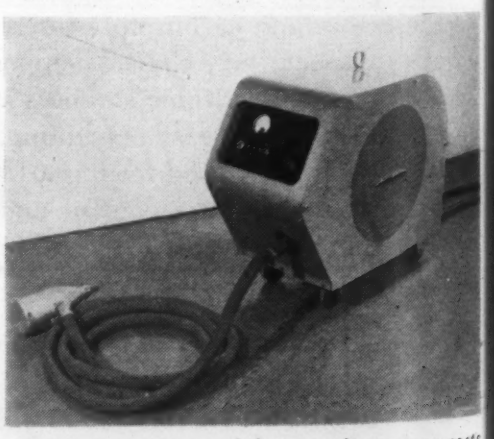
Developed by *B. F. Goodrich Co.*, Akron, Ohio, a rubber cement, Plastilock, is said to stick metal to metal with a bond stronger than that made by rivets, nuts or bolts.

According to the manufacturer, the rubber cement was first used to bond brake lining to brake shoes in motor vehicles. Latest model U. S. fighting aircraft now have brake linings bonded with the new adhesive. Since Plastilock is designed to eliminate rivets in brake lining applications, service life on the lining is said to be automatically increased 75%.

One manufacturer uses the cement to make a stronger, more serviceable gasoline tank by cementing the metal sections together. Nuts, bolts and gaskets formerly used are claimed to be needed no longer.

Submerged Arc Manual Welder

Recently announced by *Linde Air Products Co.*, 30 E. 42nd St., New York 17, the new portable, semi-automatic manual machine for unionmelt welding short seams can be used on work which cannot be welded conveniently with fully automatic machines. It is also said to be useful in



Easy operation and low maintenance costs are advantages claimed for this unionmelt portable welder.

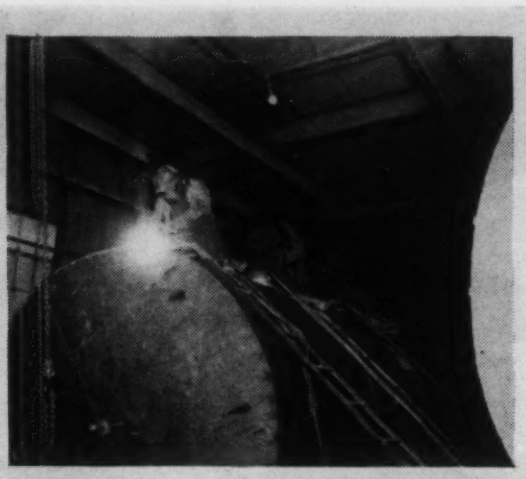
small shops which have no automatic welding machines, yet have occasional need for the labor saving and quality advantages of unionmelt welding.

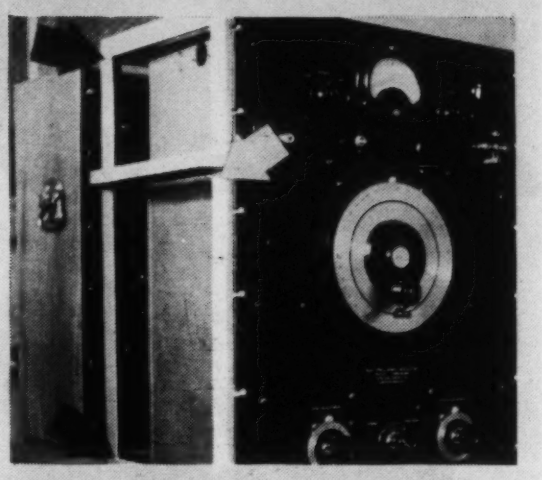
Parts of the UWM-1, which include the welding head, a voltage control box and a 75-lb capacity spoke-type rod reel, are mounted on a small steel chassis equipped with casters and a lifting eye. A 17-ft

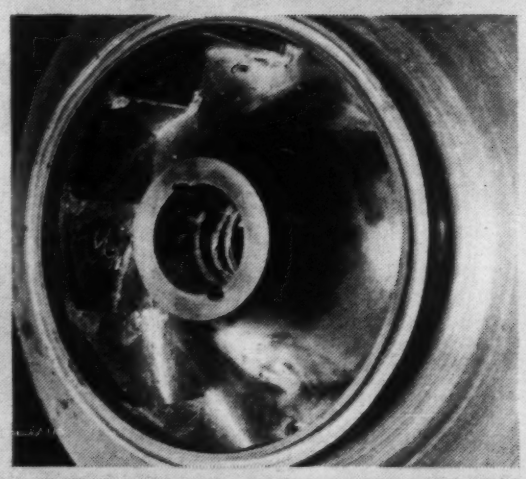
IMPORTANT: FOR YOUR DEFENSE CONTRACTS!

There's hardly a METAL-JOINING problem that Low Temperature EUTECTIC WELDING ALLOYS hasn't a better solution for!

120 JOB-ENGINEERED Low Temperature EUTECTIC WELDING ALLOYS, ELECTRODES, AND FLUXES . . .

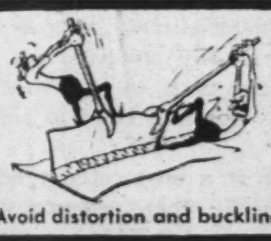






DO YOU WANT TO

Avoid stresses and cracks?



Avoid distortion and buckling?

Improve machinability?

Eliminate porous welds?

Avoid weld failures and excessive rejects?

EUTECTIC has the solution for you!

. . . easier and faster to use than conventional grades of welding rods . . . yet yielding vastly superior results and lasting satisfaction . . .

ANSWER EVERY METAL JOINING NEED

Over 78,000 users now specify genuine EUTECTIC Low Temperature WELDING ALLOYS and EUTECTOR Fluxes wherever stronger, better joints are desired . . . on ALL metals—cast iron, alloy steels, aluminum, copper and nickel alloys, die castings, overlays, etc.

It will pay YOU to keep fully posted on the selection of alloys available and the advantages of each for the particular jobs *you* face . . . for torch . . . arc . . . furnace . . . induction heating.

Free! Free! Free!

Yours for the asking: EUTECTIC's National Defense Manual Series—"Manual of Welding Engineering & Design"; "Manual of Tool & Die Salvage"; etc. Also profusely illustrated technical literature complete with specifications, case histories, etc.

Make us Prove it!

In metal-joining, the "proof of the pudding" is in the *demonstration*, not in the advertising claims. That is why we keep saying: "Make us prove it!" We gladly offer a FREE Consultation-Demonstration right in your own shop!

EUTECTIC WELDING ALLOYS CORPORATION

40-40 172nd Street • Flushing—New York, N. Y.

America's Leading Institution Devoted to Research, Manufacture of Specialized Metal-Joining Alloys

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☐ Send your local District Engineer to conduct a FREE Consultation-Demonstration in my shop.
☐ Send FREE literature on latest welding developments for the following metals_____

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CITY_____ ZONE_____ STATE_____

HOW INDUSTRY IS USING RUBATEX CLOSED CELL RUBBER

Product engineers in industries have found RUBATEX Closed Cell Rubber the ideal material for uses such as these:

Gaskets
Automobile arm rests
Anti-squeak pads
Dust barriers
Low temperature insulation
Packing cushion for fragile goods
Flotation devices
Athletic shock padding
Gymnasium mats
Kneeling pads
Crash pads
Fatigue mats
Expansion joint filler
Arctic equipment
Shoe innersoles
Typewriter cushions
Rug underpad
Seat cushions
Bath and kitchen mats
Crib and play-pen mats
Weather stripping
Vibration damping

RUBATEX is light in weight, buoyant, and has good compressive strength. It cannot absorb moisture even at cut edges. RUBATEX is rot and vermin proof and sanitary. There is a big economy factor to RUBATEX. Most gasket requirements can be cut from sheet stock without need for the expense of a molded-on skin. RUBATEX is available in natural and synthetic stocks and in soft, medium and firm forms. For more information, write for Catalog, RBS-12-49, Great American Industries, Inc., RUBATEX DIVISION, BEDFORD, VIRGINIA.

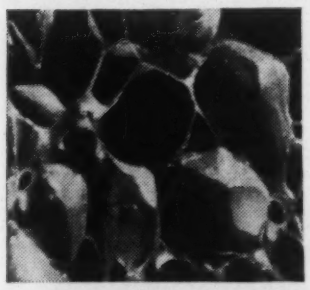


Photo-micrograph of RUBATEX closed cellular rubber shows the tiny individually sealed balloon-like chambers which retain inert nitrogen under pressure.

RUBATEX

CLOSED CELL RUBBER

ZERO MOISTURE ABSORPTION

RESILIENT AT LOW TEMPERATURES

EXCELLENT SHOCK ABSORPTION

New Materials and Equipment

flexible hose connects the hand unit to the welding head.

Industrial Adhesives

A series of four industrial adhesives are now offered by *Houghton Laboratories, Inc.,* Olean, N. Y. Available in liquid, powder and rod forms, these materials can be cured at room or elevated temperatures, depending upon bond strength desired.

Liquid Adhesive 101, composed 100% of solids, is a cold-setting adhesive recommended for bonding metal to metal, glass to glass, ceramics to ceramics and hard rubber to glass, metal or wood. It is prepared by adding a hardening agent to the base prior to application.

The second in the series, Liquid Adhesive 102, is supplied as either medium or low viscosity material and contains solvents. It is primarily intended for use where one of the parts to be bonded is porous—such as bonding cloth to plastic, etc.

Solid Type 1 is a heat cured adhesive said to be applicable where optimum shear strength is desired. Available as powder or in rod form, it is cured by forced heating—with temperature and length of exposure to heat determining bond strength. Using this material in either powder or rod form, shear strengths of 5000 psi are said to be obtained in lap joints of aluminum to aluminum.

The last in the series, Liquid Type XV, a liquid version of Solid Type 1, is a high solids solution of the adhesive in a solvent. It is designed for such products on which spraying, brushing or dipping methods are preferred. After coating, the parts can be stored up to six months before bonding.

Forming & Machining

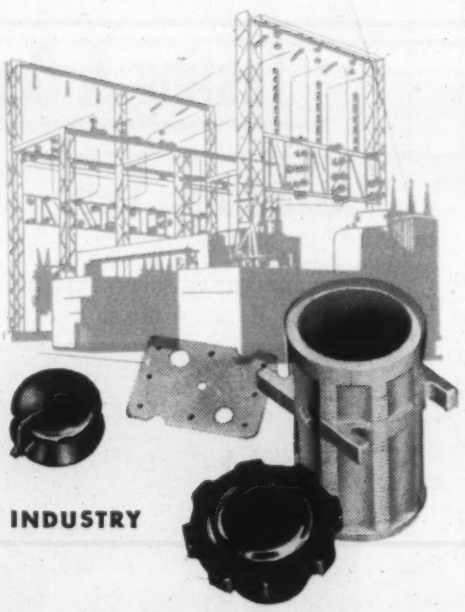
Contact Wheel

An entirely new type of contact wheel for abrasive belt application on backstand idler applications of many types in the metallurgical field has been announced by *Carborundum Co.,* Niagara Falls, N. Y.

Said to permit the operator to get twice as much production in those operations where glazing normally occurs from a standard abrasive belt than that obtained with any previously used, the new 61 wheel is a specially serrated rubber wheel that causes a controlled breakdown in the bond of the abrasive belt. The result is that

When you need a versatile material

micarta is basic!



ELECTRICAL INDUSTRY

MICARTA® can take any shape. It is a tough and resilient basic material . . . a plastic which can be machined, formed or molded to micro-fractions of an inch.

MICARTA is lighter than aluminum. Pound for pound, it has a greater compressive strength than structural steel. It cushions impact, resists heat and cold, outlasts metal in many punishing applications.

Here is an excellent insulator. It is a standard in panels, switch handles, separators...wherever electric current has to be isolated.

This versatile basic material fabricates easier and more economically than any metal. Do you have a place for it? Westinghouse Electric Corporation, MICARTA Division, Trafford, Pennsylvania.

J-06447

You'll find MICARTA across the board in this vital industry. For over 40 years, MICARTA has served as a basic material wherever electricity is generated or used . . . from central station applications to home appliances . . . as large fabricated panelboards or tiny punched radio and television parts.

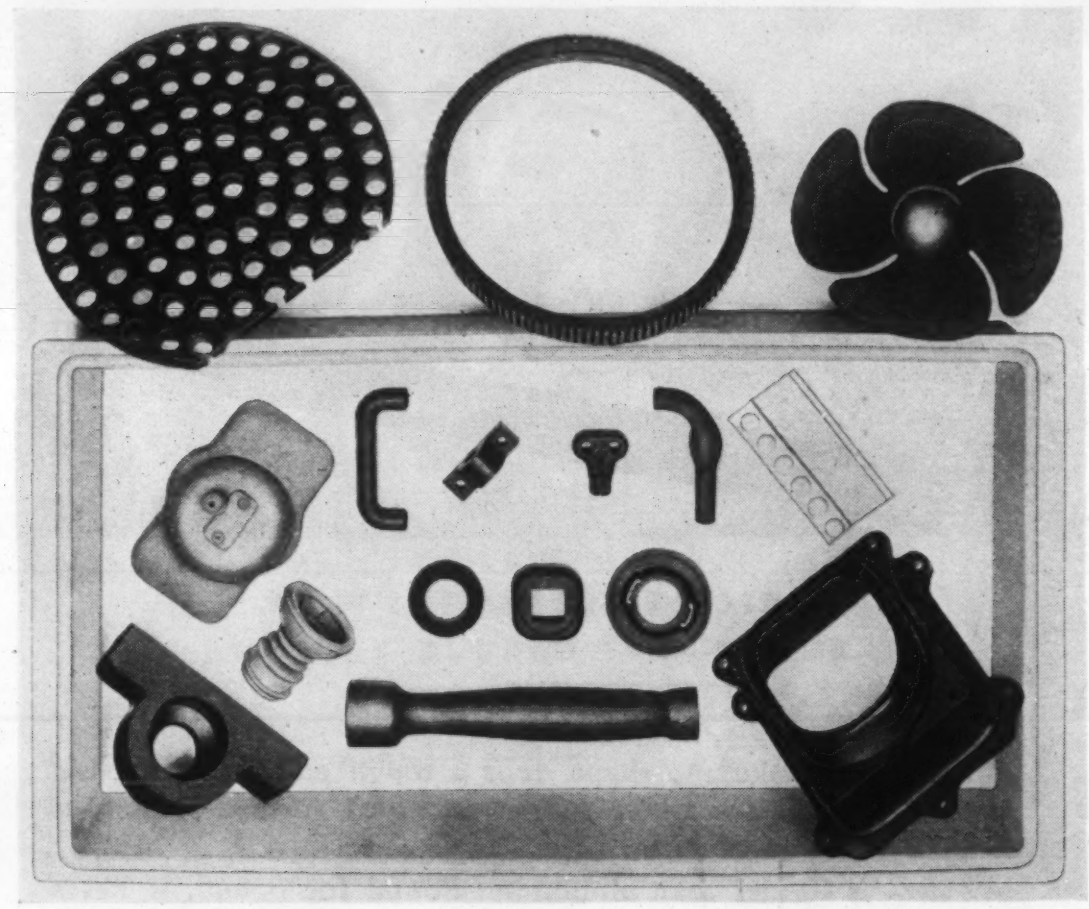
YOU CAN BE SURE.. IF IT'S Westinghouse

WESTINGHOUSE

Micarta

RUBBER

An Ever Widening Circle of Uses



Rubber is playing an increasingly vital part throughout industry. Modern compounding has developed natural rubber and synthetic polymers into ideal materials for applications in which they could not have been considered a few years ago. Today, rubber molded parts with unusual properties and characteristics that overcome problem conditions are replacing standard materials that have inherent deficiencies for many applications.

ACUSHNET has every modern facility and technique for molding rubber parts and products with absolute precision.

Acushnet
PROCESS COMPANY
New Bedford, Mass., U. S. A.

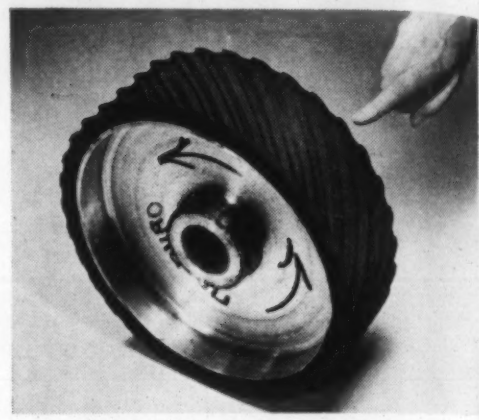
Send for Rubber Handbook on your company letterhead

Address all communications to 750 Belleville Ave., New Bedford, Mass.

New Materials and Equipment

glazing is reduced to such a degree that belt life is doubled.

While the idea of a serrated rubber contact wheel is not new, the characteristics of the new wheel—the relief angle, wide-



This new contact wheel is a specially serrated rubber wheel that causes a controlled breakdown in the bond of the abrasive belt.

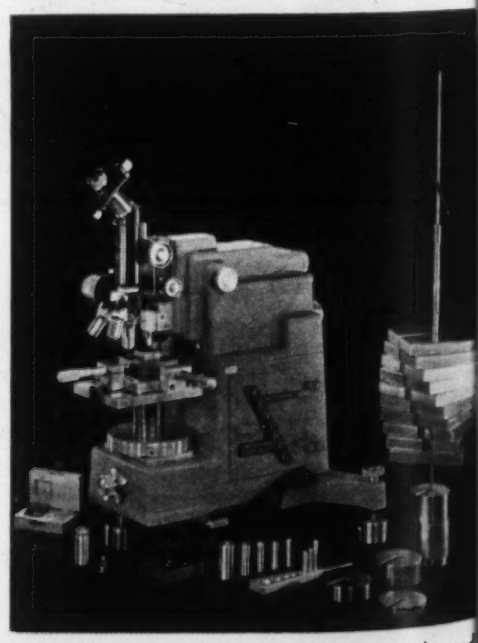
spaced lands, narrowness of the lands—are entirely new developments.

In addition to longer life and high stock removal rates, the new wheel, according to the manufacturer, reduces the number of belt changes and permits a more uniform finish.

Testing & Control

Microhardness Tester

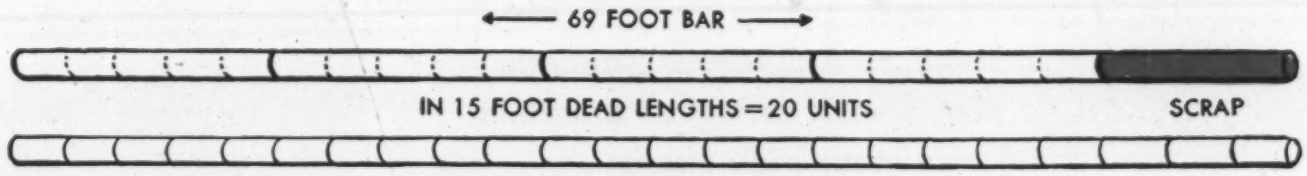
Kent Cliff Laboratories, Peekskill, N. Y. has announced several major improvements in the Kentron micro hardness tester used



This improved microhardness tester is used for making Knoop or Vickers tests on metals, plastics, etc.

What you can do to make the supply of Stainless Steel go further

Minimize scrap losses at the mill by ordering the exact sizes that you will use



When you order sheets, plates or bars of Stainless Steel, don't confine your specifications to mere "dead lengths." Such procedure often leads to a waste of material.

Instead, place your orders in terms of *multiple lengths*. In other words, tell your supplier the actual dimension in which you will eventually use the steel. By doing this, you'll often get *extra* units from good steel that otherwise would be consigned to scrap.

For example, suppose you've been ordering 15-foot bars and are using the steel in 3-foot units. If the mill should roll a 69-foot bar, we could cut only four lengths or 20 3-foot units from it. But when ordered in multiple lengths, we could cut 23 units from the same bar, and scrap losses would be minimized.

The same thing holds true when you are ordering sheets, strip, or plates. The more we know how you will use the steel—the actual sizes you are planning to work to—the more chance we have of taking care of your requirements.

Cooperation from all concerned will stretch supplies of Stainless as far as possible. Specifying multiple lengths is one way you can help. (And it's equally important in your orders for alloy steels and plain carbon steels, too.)

Keep these points in mind, too, when you order Stainless.

Tell your supplier exactly where you'll use Stainless and how you'll fabricate it.

Indicate, if possible, acceptable alternates in composition, gage and finish.

AMERICAN STEEL & WIRE COMPANY, CLEVELAND · COLUMBIA STEEL COMPANY, SAN FRANCISCO
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UNITED STATES STEEL

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Fast delivery is a special feature of Barrett service. Convenient coast-to-coast stock points make it easy. When you buy Barrett Standard Anhydrous Ammonia, you know you can depend on speedy arrival of ammonia of unexcelled purity and consistent high quality.

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New Materials and Equipment

for making Knoop or Vickers hardness tests on metals, fine wire, small precision parts, plastics, glass, paint, ceramics, and enamels and jewels, both natural and synthetic.

The testing load range of the instrument is said to have been increased 10-fold. It now applies dead weight loads from 1 to 10,000 grams.

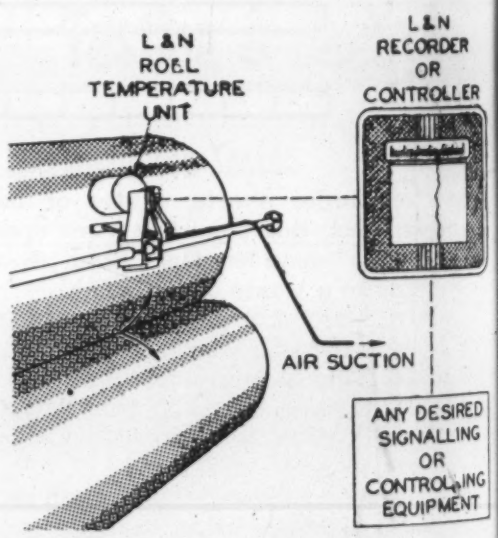
Another improved feature is that the mechanical stage is so designed that the specimen slides underneath high powered objectives up to and including 1000 times magnification—without disturbing the original focusing of the microscope.

Frictionless leveling of the tester is said to be provided by three supporting pads which, when required, can be arranged for shock or vibration mounting.

Surface Temperature Detector

A new roll surface temperature unit, developed by *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia 44, is said to measure the temperature of a moving roll surface without touching the roll.

Because of this unique design, it cannot scratch, score or in any way destroy deli-

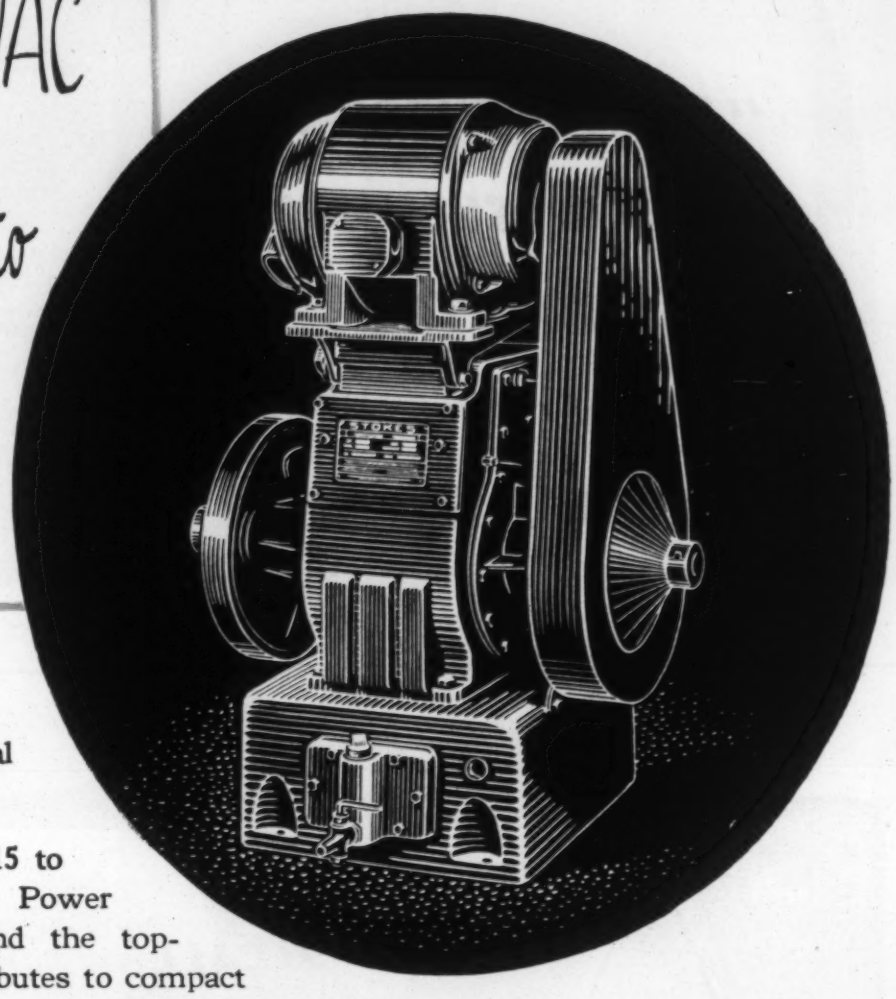


This surface temperature detector is said to measure the temperature of a moving roll surface without touching the roll.

cate surface films. Temperature detected by the unit is recorded automatically by either a Micromax or Speedomax instrument supplied as an integral part of the complete equipment.

Claimed to be applicable to roll diameters down to 9 in. and to flat surfaces, the new unit operates independently of surface speed, emission characteristics and finish. It can be mounted at the center of the roll or at any other location, wherever actual temperature measurement is desired.

STOKES MICROVAC PUMPS...are basic to Vacuum Processing



High volumetric and mechanical efficiency make these famous pumps economical and reliable units in any vacuum system.

Capacities of Stokes Microvac Pumps run from 15 to 500 cfm . . . pressures to 10 microns absolute. Power consumption is low and the top-mounted motor contributes to compact design requiring minimum floor space.

Lubrication of the four moving parts (including the exhaust valve of corrosion-resistant Teflon) is fully automatic. There are no stuffing-boxes or grease fittings, and no packing.

Parts are precision-finished, standard and interchangeable. Freedom from wear assures years of trouble-proof service.

Stokes is the only manufacturer of equipment for complete vacuum systems, including Microvac mechanical pumps, oil diffusion pumps, McLeod Gages and Vacuum Valves.

Send for FREE Stokes Vacuum Calculator. This slide rule determines needed pump capacity for any job...shows Centigrade to Fahrenheit conversion. Other useful conversion tables and scales on reverse of rule.

Consult with Stokes on the application of vacuum to vacuum sintering, melting, de-gassing, heat treating, inert gas purging, vacuum metallizing, and to other applications in which vacuum deserves exploration.

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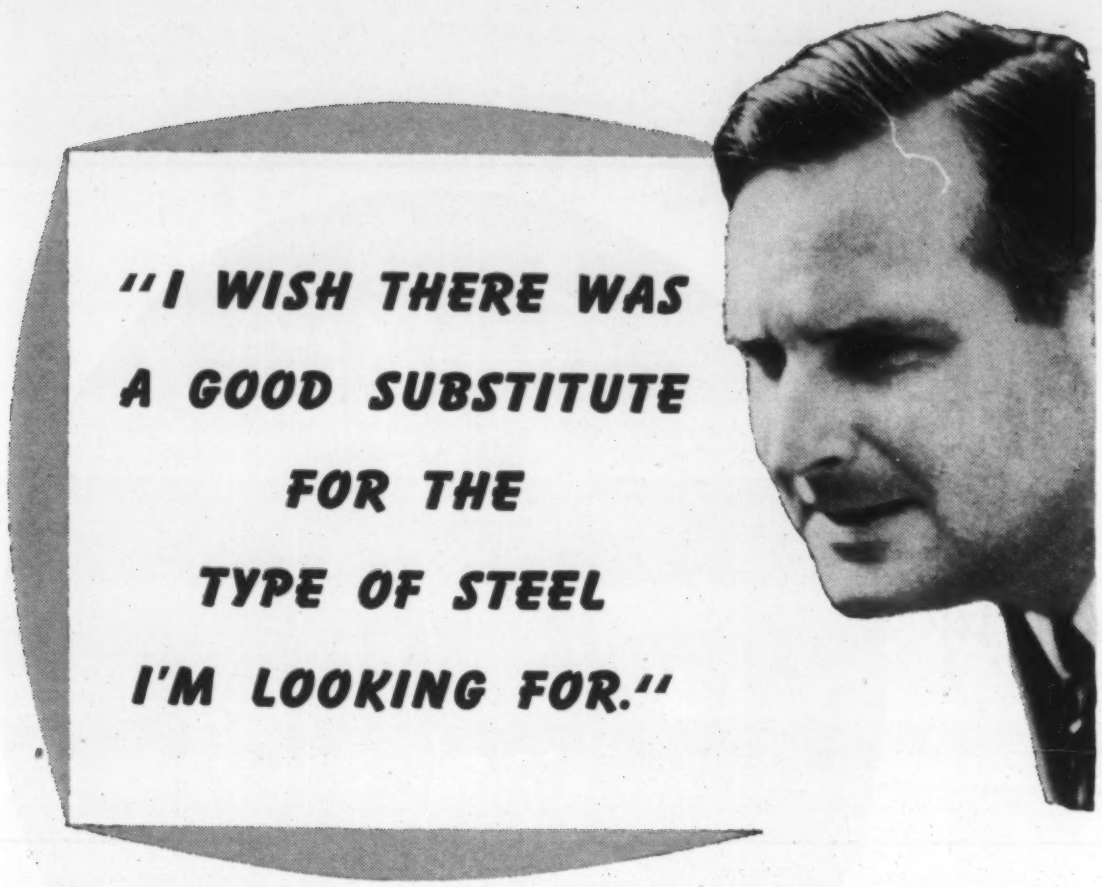

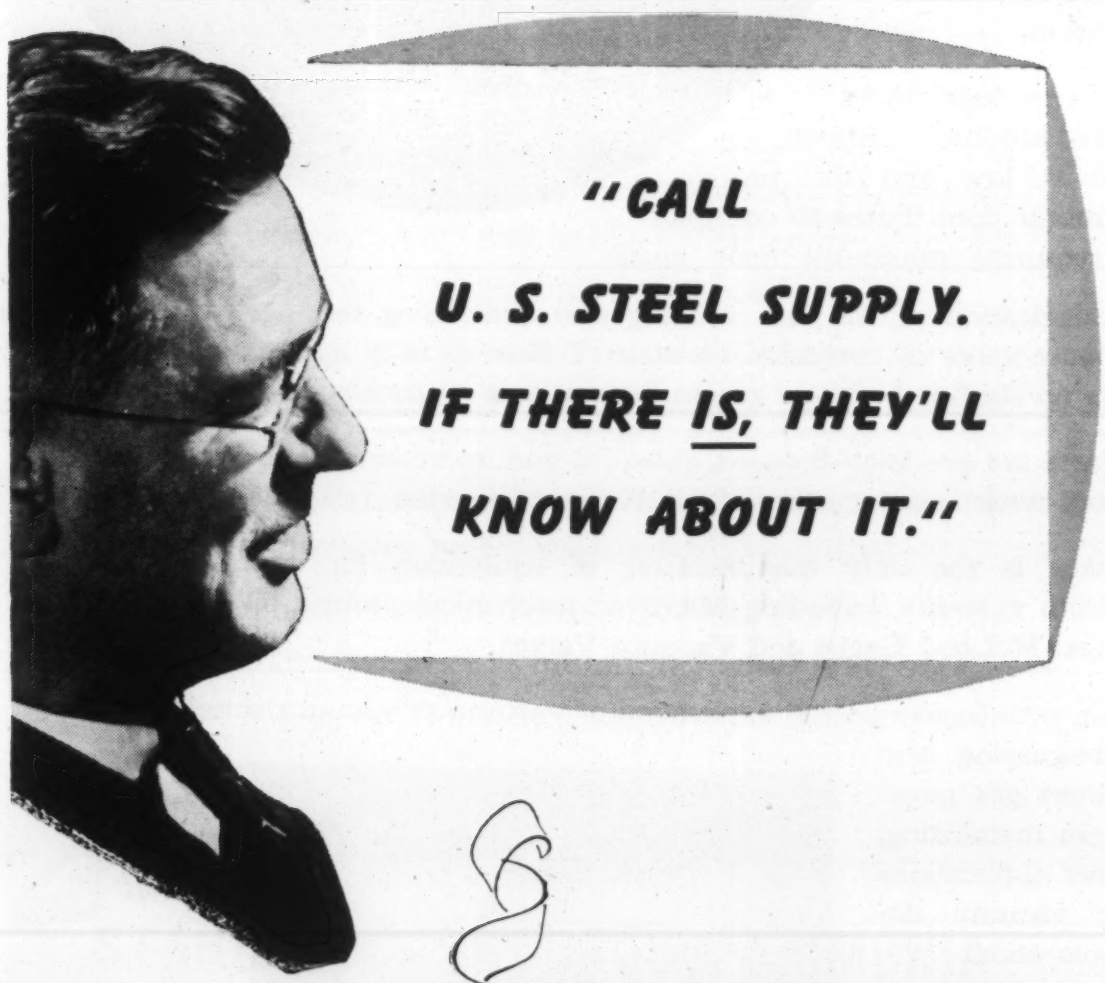

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UNITED STATES STEEL

A LETTER TO THE EDITOR

To the Editor:

Two recent articles in MATERIALS & METHODS dealing in part with beryllium copper, present certain inconsistencies which should be brought to the attention of your readers. The first, "How Copper-Base Alloys Are Used in the Electrical Industry" by R. A. Colton (December 1950), includes the following statement regarding beryllium copper:

> ". . . beryllium copper alloys are difficult to manufacture in the foundry and offer considerable difficulty in machining."

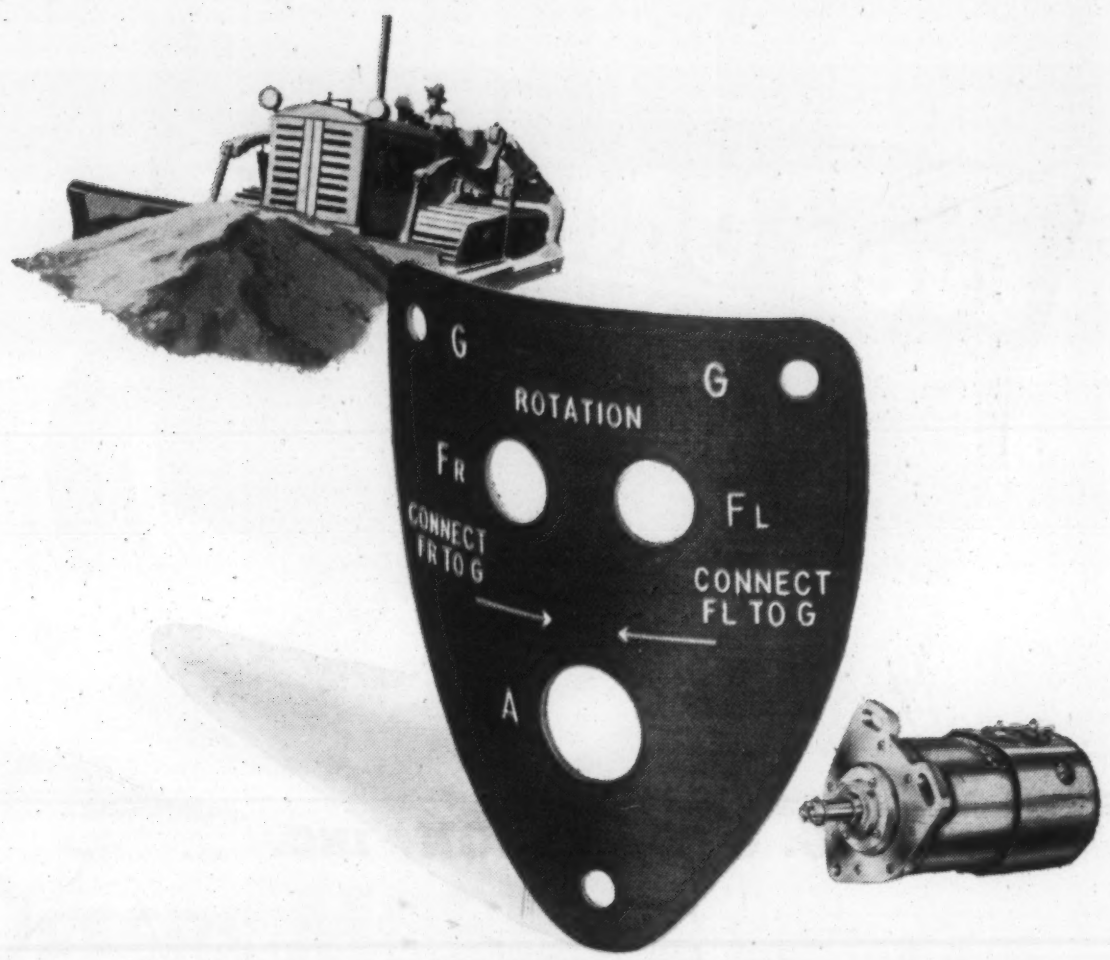
While beryllium copper is not a free-cutting material in the sense of leaded brass, it can be readily handled with the proper cutting speeds and tools. In the unhardened condition, beryllium copper compares favorably in machinability with copper and other copper alloys, including phosphor bronze, nickel silver, cupro nickel and aluminum bronze. Although beryllium copper is singled out by the author as being difficult to machine, it probably is no more difficult to handle than many other alloys listed in the author's Table I.

By stating that beryllium copper is difficult to manufacture in the foundry, it is implied that beryllium copper has poor running or casting qualities. This opinion may originate from people inexperienced with beryllium copper; however, foundries regularly handling this alloy report excellent castability. For example, Wood and Ludwig (MATERIALS & METHODS, January 1951) claim:

> "The fluidity of the red and yellow brasses and bronzes is inferior to either beryllium copper or silicon brass, the latter of which is most generally credited with maximum fluidity. But the powerful deoxidizing effect of the beryllium in alloys containing it makes them as fluid as silicon brass when proper foundry melting equipment and controls suitable for handling the rather sensitive beryllium-containing metals are used."

For many precision castings where high mechanical properties are of secondary importance, beryllium copper is frequently selected solely on the basis of its superior casting characteristics. This is particularly true in the case of certain complex investment castings where the elimination of machining operations or the reduction of rejects may mean lower overall costs. Similarly, beryllium copper is frequently employed for

(Continued on page 140)



How to move mountains—non-stop

When it comes to moving mountains—or spreading the landscape around—you can't beat bulldozers.

You can, however, beat a bulldozer if you put into it a part that can't stand the gaff.

An example is the generator. Vibration, abrasive dust, weather, shifting stresses and stray oils or greases are constantly taking their hardest licks at it. It leads a tough life.

That's why American Bosch Corporation, makers of dust-proof, heavy-duty generators for industrial tractors and bulldozers, selected Synthane laminated plastics for the insulation plate shown above.

Synthane is a material for industry. It possesses an unusual *combination* of physical, mechanical, chemical and electrical properties.

Synthane is light, strong, dense, abrasion resistant. It is easily machined or produced in formed shapes. Dielectrically strong, it is a natural for electrical applications. Synthane is corrosion and fungus resistant, chemically inert, stable over a considerable temperature range.

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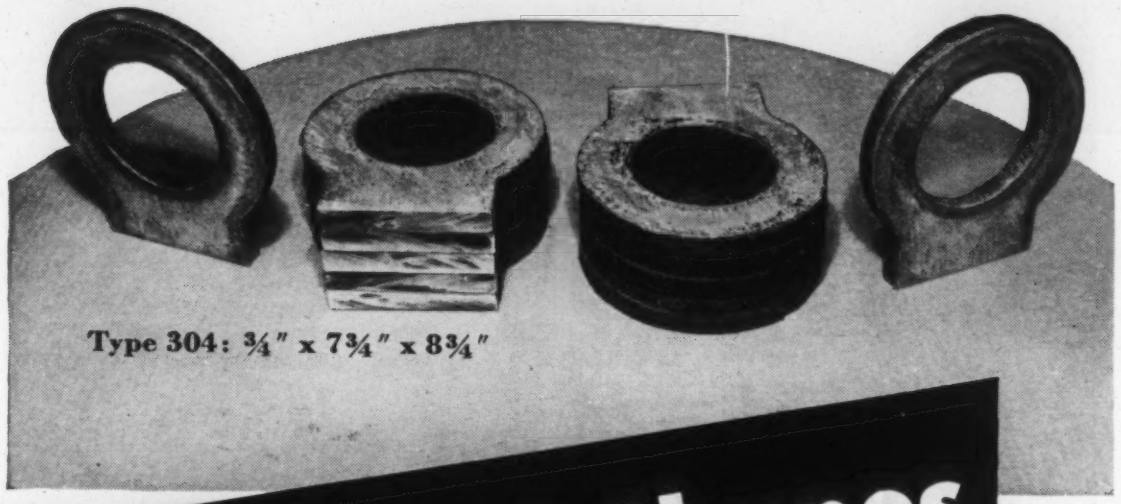

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A Letter to the Editor

(continued)

sand or pressure cast mold cavities for plastics, since it offers needed detail with little or no machining.

In addition, several brass foundries add small quantities of beryllium to regular brass and bronze casting alloys to increase fluidity for certain tough jobs. Tests of the spiral type show small quantities of beryllium (0.1 to 0.2%) increase fluidity of certain brass alloys by more than 33%.

The author's Table I lists the compositions and properties of several beryllium copper alloys. One of the most important alloys from an electrical standpoint is not included. This alloy has the following nominal composition: 0.5 beryllium, 2.5% cobalt, balance copper. For additional information on this and other commercially available beryllium copper casting alloys, see MATERIALS & METHODS (April 1950, page 75) or (September 1949, page 70).

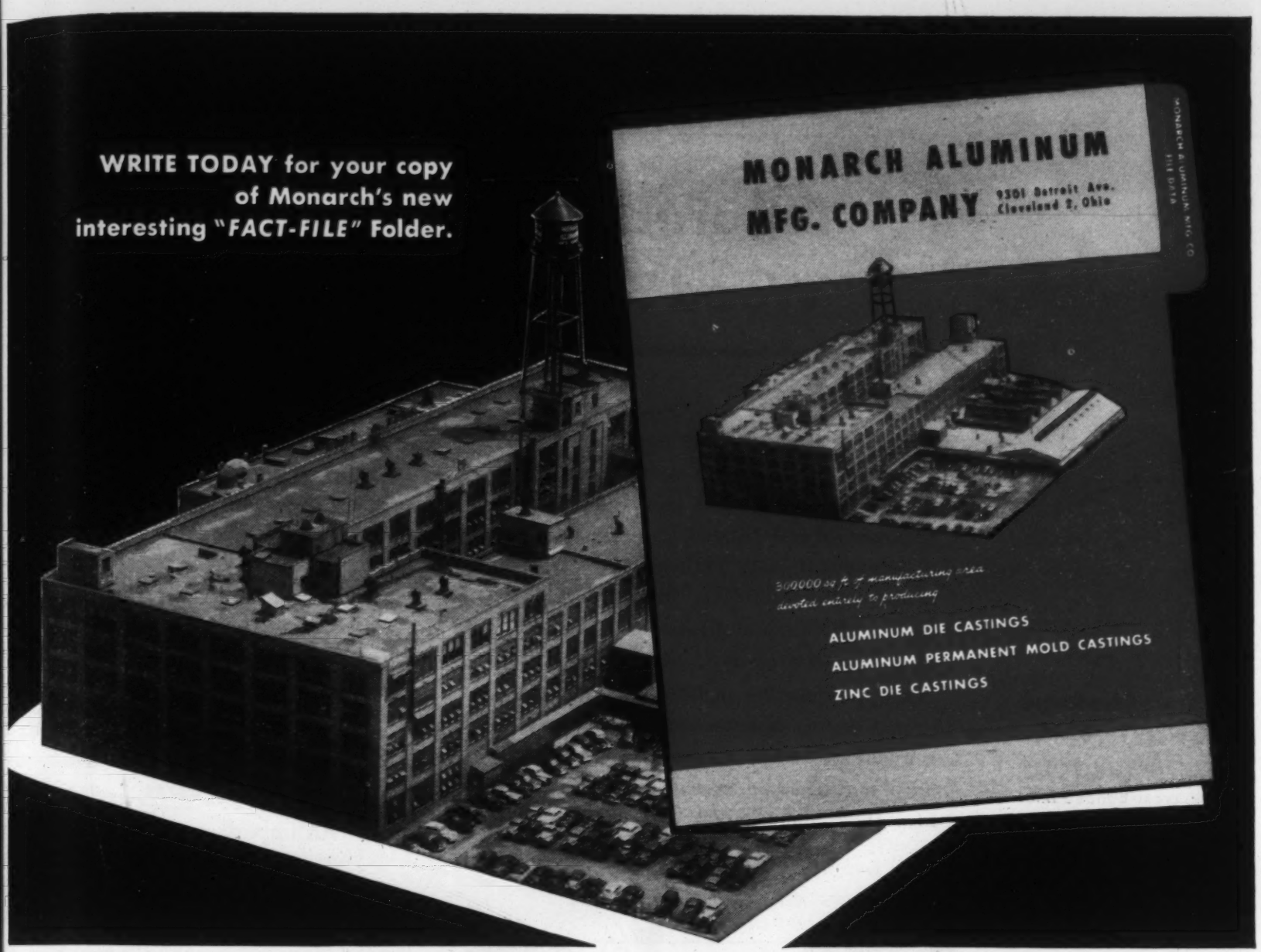
In the second article, "How to Select Nonferrous Alloys for Investment Casting" by R. L. Wood and D. V. Ludwig (MATERIALS & METHODS, January 1951), it is stated that it is necessary in handling beryllium copper to tailor heat treating cycles to conform to the responses of each heat. From our experience, we have found this to be necessary only in the case of special under-aging or overaging treatments designed to produce unusual combinations of properties.

Casting alloys are not particularly sensitive with respect to composition, so that a single aging treatment can be applied to alloys ranging from 1.6 to 2.9% beryllium. Under normal melting conditions beryllium losses average 0.12%, so that scrap can be safely remelted several times without affecting hardening response. For best results, it is recommended that each furnace charge should include some virgin pig as well as clean scrap.

In our own operations, we have successfully applied a single aging treatment (3 hr at 600 to 650 F) with our 2% beryllium casting alloy for a number of years. In handling the many heats run over this period of time, standard brass or bronze foundry equipment and techniques have been employed with good results. Oxidation, which is held to a minimum, does not influence hardness response and, being largely confined to the surface, is readily removed by usual cleaning procedures.

J. T. Richards

The Beryllium Corp.
Reading 3, Pa.



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Monarch's casting production in aluminum permanent mold, aluminum and certified zinc die castings is recognized throughout industry. Monarch offers the obvious benefits of this coordinated service... *in one plant, under one management.*

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Tailored Wood?

YES . . . tailored to rigid "ready-to-work" standards which make it more versatile, more workable and more useful than wood has ever been before. Tailored for *type:* waterproof-bond Exterior . . . moisture-resistant Interior. Tailored for *grade:* several within each type. Tailored for *performance:* Douglas fir plywood meets a wide range of diverse needs . . . fits thousands of jobs in construction, maintenance, product improvement, manufacturing, packaging, shipping. Measure this modern real wood panel material against *your* requirements. Mail the coupon, today!

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Large, Light, Rigid
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Rugged, Durable
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Easy to Handle
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Easy to Nail
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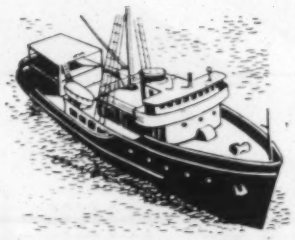
*Two types: waterproof-bond EXTERIOR; moisture-resistant INTERIOR. Several appearance grades. Panels 4′x8′ most versatile; smaller and larger sizes, too—including "extra long". Several thicknesses. Produced to rigid requirements of U. S. Commercial Standard CS45-48.



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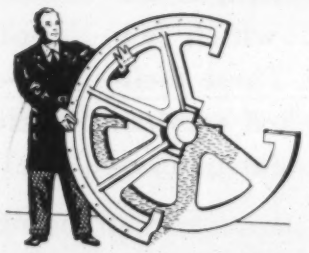

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News Digest

Powder Metallurgy in Defense

(continued from page 13)

der metallurgy is fitting into the defense program, A. J. Langhammer, Amplex Manufacturing Co., reviewed the progress of the Powder Metallurgy Committee in the American Ordnance Assn. The major part of their work has been concerned with advising the Ordnance Corps on the availability of metal powder production and fabricating facilities which could be employed for the manufacture of iron powder rotating bands. It is the belief of the Committee that if the facilities presently contemplated are fulfilled, no shortage to meet present Ordnance requirements is expected.

Metal Powder Cores

An important and growing use of powdered materials, including iron and ferrites, is in high-frequency transformer cores for radio communication equipment. H. W. Lord, of the Research and Development Board, Dept. of Defense, ably reviewed this application in his paper "Powdered Iron Materials in High Frequency Transformers for Military Equipment".

By making possible considerable savings in space, powdered iron core materials provide the means necessary to miniaturize the most common type of high-frequency transformers, which are known as an intermediate-frequency (i-f) transformer. Even further size reductions are possible by using ferrite cores.

Some of the advantages of the ferrites are off-set to a small degree by the effect of temperature upon their initial permeability. Also, the Curie points of some ferrites are less than 212 F but the Curie points of others are above 482 F. They are also limited to applications in the low-frequency range of the radio spectrum. A few are good for use up to 20 megacycles, but the majority are not satisfactory when used at frequencies above 5 megacycles.

Other Papers

An interesting paper, "Powder Metallurgy Versus Drawn Wire Method of Producing Gears", was presented by J. Rigby of John Rigby

Customer Reports:

Asarco Continuous Cast Bronze Saves 20% in Metal Cost, Production Time

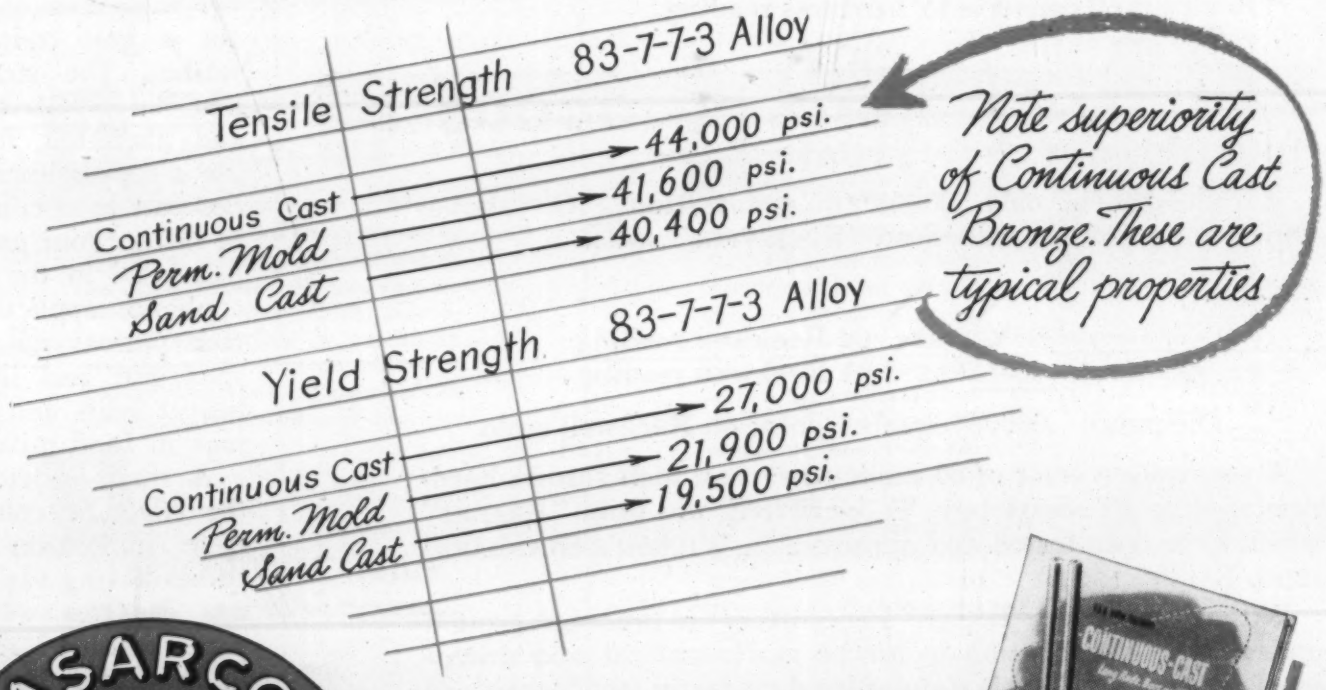
A manufacturer of packaging machinery tells of saving 20% in production time and 20% in material cost when he makes shaft bearings and nuts of Asarco Continuous Cast Bronze.

The patented Asarco casting process guarantees him bronze rod that is free from the hard and soft spots so often found in sand cast bronzes. Stock is exceptionally uniform and free from porosity. Since sand is not used, and dirt and dross are excluded, there can be no surface or internally trapped abrasive to dull tools or discourage high cutting speeds. Rejects are virtually unknown.

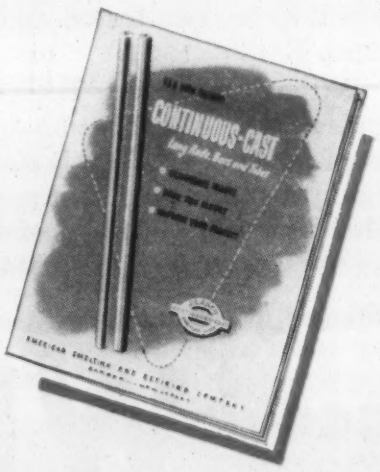
Dimensions are held to extremely close limits. For example, tube concentricities are within 1.5% of wall thickness. Dimensional uniformity is assured . . . machining on automatics is standard practice.

Continuous Cast Bronzes can be made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in all principal cities. Distributors will cut this stock long or short to suit your needs.


Tensile Strength 83-7-7-3 Alloy
Continuous Cast → 44,000 psi.
Perm. Mold → 41,600 psi.
Sand Cast → 40,400 psi.
Yield Strength 83-7-7-3 Alloy
Continuous Cast → 27,000 psi.
Perm. Mold → 21,900 psi.
Sand Cast → 19,500 psi.
Note superiority of Continuous Cast Bronze. These are typical properties

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®



Send for this free catalog on Asarco Continuous Cast Bronzes. It contains physical properties, table of weights, photomicrographs, table of stock shapes and sizes and other data.

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Sphero-Conical Diamond BRALE* Penetrator for Hardened Steel

A. Minor load penetration

B. Major load penetration

C. Linear measurement of penetration increase which "ROCKWELL" converts to hardness reading

A Difference of only .00008"!

A difference of only .00008" in penetration ("C" above) equals one point of hardness on "ROCKWELL" scale.

Example:

"C" equals .00320" at C 60 Rockwell reading
"C" equals .00312" at C 61 Rockwell reading

Difference .00008" equals 1 point on Rockwell scale

A penetration error of 80 millionths of an inch throws hardness reading off completely. To be SURE, use only "BRALES" which have been tested and approved in WILSON'S STANDARDIZING LABORATORY.

Wilson's Diamond "BRALE" Penetrators are precision ground under high magnification to assure mathematical and microscopic accuracy. Each is standardized on many test blocks and rigidly inspected before it receives the Wilson stamp of approval. The degree of accuracy of "BRALE" Penetrators makes them highly satisfactory for research laboratory work.

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News Digest

& Sons, Ltd., England. The author pointed out that both methods have many similar advantages, such as the elimination of machining, reduction of waste, and relatively low cost. However, if the gear form is really suited to powder metallurgy, such as a pinion or special cam, it can be produced cheaper than from wire. But powder metallurgy methods cannot compete where the gear shape can be obtained by cold drawing in just one or two passes. He concluded that metal powder parts will slowly but surely encroach into the structural parts market, which is at present supplied by the precision cold drawn process.

Metal powder parts have met with outstanding success in many household products. The successful use of them in General Electric appliances over the past six years was described in the paper "Metal Powder Applications in the Home Appliance Field", by J. D. Carey. One of the first uses of iron powder was for a gear train in an automatic washer. The straight iron powder part did not have sufficient strength and, therefore, it was necessary to use a copper impregnated iron powder part to obtain a sufficient factor of safety. Four gears of this type are now used in the mechanism. Other appliance applications now include rack pinions in washing machines, spur gear and link in home fans, helical gears and self-aligning bearings in food mixers.

A study undertaken to determine the effect of complete and incomplete infiltration in iron powder bodies having various uniform skeleton densities was described in a paper entitled "The Flywheel Effect in Infiltrated Metal Powder Parts", by G. Stern, American Electro Metal Corp. The most significant finding of this study was that by the infiltration process a complicated shape can be formed with varying density in various sections, and that the infiltration itself will equalize the physical properties in these sections. Thus, if infiltration is performed after coining, the copper will infiltrate the low density areas, bring it up to 100% infiltrated density so that the areas will exhibit high strength despite low iron skeleton

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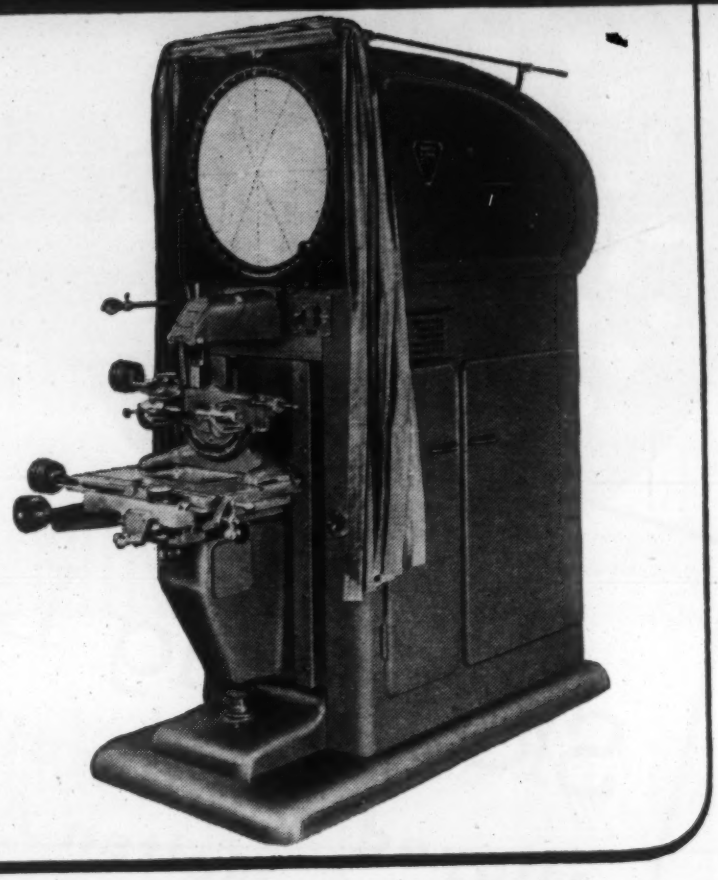
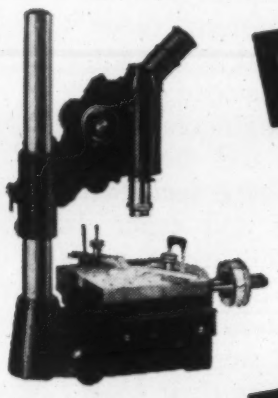


You save time and money by assuring *more accurate measurements than any other projector can give you.* You get angular measurements to ±1 minute of arc, with the protractor screen. You get direct linear measurements to ± .0001" over a range of 4"x6", with the cross slide stage.

You save time and money by spotting inaccuracies quickly and simply. Dimensions, angles, and profiles of production-run parts can be compared directly with a *traced outline* of the projected image of the master part, or with a large scale drawing superimposed on the screen. Catalog D-27.



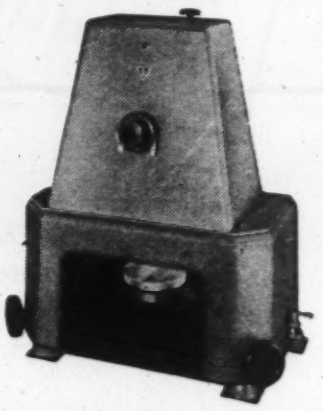
2 TOOLMAKERS' MICROSCOPE

Linear measurements to ±.0001", and, when fitted with a protractor eyepiece, angular measurements to ± 1 minute of arc, can be made with this sturdy microscope. Operation is extremely *simple* and *fast.* Opaque and transparent objects of any contour can be measured. *Catalog D-22.*

3 STEREOSCOPIC WIDE FIELD MICROSCOPES

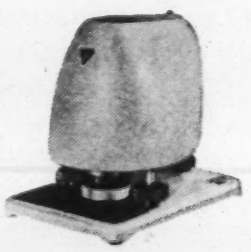
Provide clear, sharp, 3-dimensional, unreversed, magnified images. Used extensively in industry for greater speed and accuracy in small parts assembly operations, inspection of tools and finished parts, and precision machining of small parts. 15 models for many uses. *Catalog* D-15

New 4 PARA-PLANE GAGES



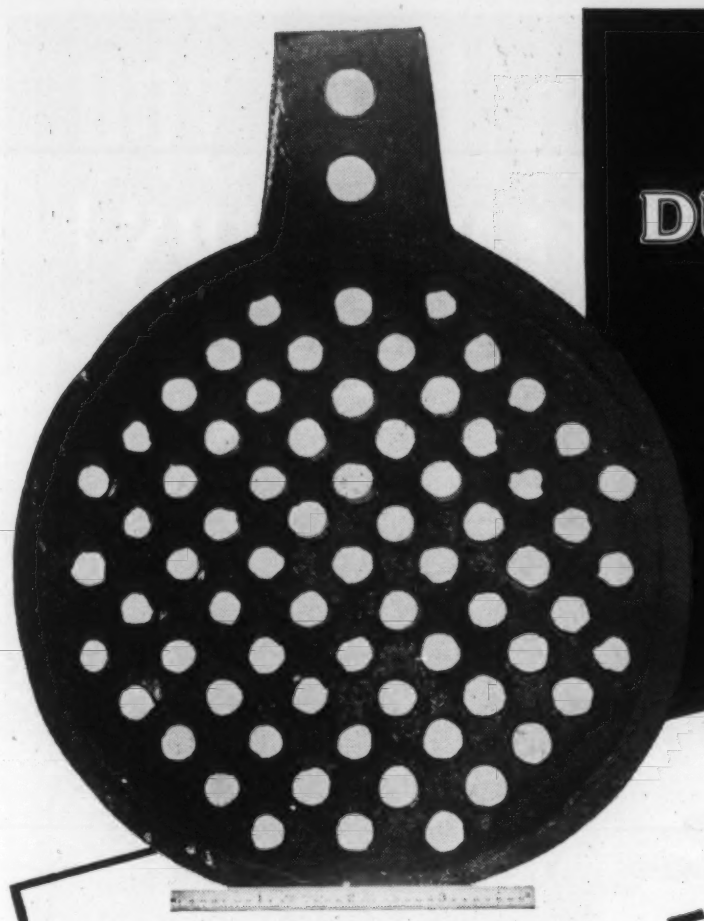
Now you can have "laboratory" accuracy of 0.000001" in the determination of flatness and parallelism of reflecting surfaces... with production-line *simplicity* and *speed.* So simple that an unskilled operator can make measurements after a few minutes of instruction.

Two sizes of Para-Plane Gages are available: the larger (top) tests objects up to 6" in diameter; the smaller (bottom) tests up to 3" in diameter. *Bulletin* D-224.



WRITE for complete information on these 4 important optical aids designed to help you save time and money. You may be paying many times over their cost in lost time and rejects. Send your request to Bausch & Lomb Optical Company, 793-6 St. Paul Street, Rochester 2, New York

Bausch & Lomb *Quality Control* Instruments



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Alloyed and Duralized for Handling Molten Aluminum

This is a high chrome alloy — 24% chromium and 12% nickel — an excellent alloy for meeting the conditions imposed when handling molten aluminum. As you can see the casting is approximately 6 inches in diameter — not a big casting as many Duraloy products go but indicative of what we can do in the way of small castings.

Our experience in this business of high alloy castings goes back to 1922 and we also pioneered work in the centrifugally cast high alloys which we inaugurated back in 1931. So we have much to offer those requiring chrome-iron, chrome-nickel and nickel-chrome castings. Plenty of experience, skilled metallurgists and foundrymen, modern testing and analytical facilities, and one of the most up-to-date and fully equipped high alloy foundries in the country.

We'll be glad to help (1) in the design of the part you need to produce the strongest casting and (2) to advise in the alloying elements to produce the most durable casting.

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density. Where density of iron skeleton is already high, infiltration further aids the strength.

New Officers

The new officers of the Metal Powder Association elected for the coming year are: president—T. L. Robinson, Wel-Met Co.; vice president—E. H. Klein, New Jersey Zinc Sales Co.; chairman of the board—W. P. Schenck, Scrub Oaks Div., Alan Wood Steel Co.; directors—W. E. Cairnes, Radio Cores, Inc.; F. H. Mulligan, Charles Hardy, Inc.; and R. P. Seelig, American Electro Metal Corp.

New Sapphire Laboratory Crucibles Developed by Air Force Scientists

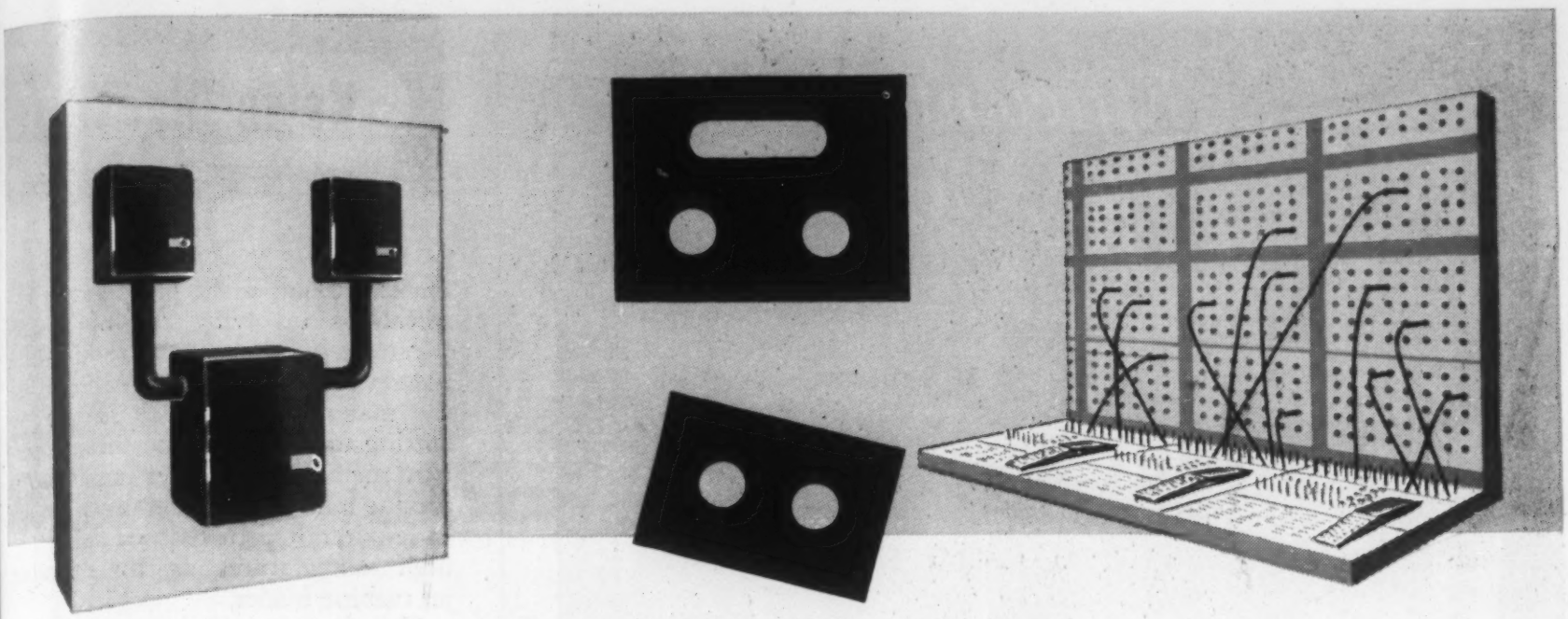
To chemists and metallurgists, a sapphire is more than just a precious stone used for purposes of adornment. It also is an excellent example of aluminum oxide in pure state. Industry uses aluminum oxide to make aluminum metal. It is a white powder refined from bauxite ore.

Recently, engineers of the Office of Air Research and the Materials Laboratory here have succeeded in making crucibles and other laboratory ware from this oxide powder. The crucibles are polycrystalline in structure, but gem-like in quality. Jewel sapphires are single crystals, and the blue ones derive their color from the presence of foreign oxides, such as titanium.

The crucibles, actually 99.8% pure, have a transparency that rivals the finest English Bone China. But they are far stronger. They will not break when dropped from a height of several feet. Their material is nonporous and is not subject to chemically-induced changes. It is also highly resistant to corrosion.

Thus, the crucibles lend themselves well for laboratory purposes. The material has a compressive strength of approximately 500,000 psi. And it retains its strength up to a temperature of approximately 2000 F. At this temperature most metals will already have reached a plastic state. Low temperatures do not affect the material.

Air Force engineers say the new



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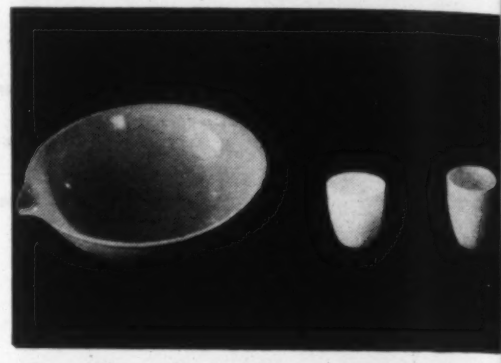
material holds great promise for applications involving the high temperatures necessary to melt super-hard metals. Also, it may be possible to use the material as an alloy in making cutting tools to machine these super-hard metals. Still another possibility is mixing metal and the ceramics for use in jet aircraft parts that are subject to high temperatures, as, for example, jet turbine blades.

The pioneers of the process used to form the oxide into a stable structure are Dr. E. Ryschkewitsch and



Gem-like polycrystalline aluminum oxide, or sapphite, crucibles have been made by engineers of the Office of Air Research for laboratory purposes in melting super-hard alloys.

Adolph Strott, former German scientists now employed by the Air Force. The two men began their research in the early 1930's while still in Germany. They have continued their investigations for the USAF through the office of Air Research.

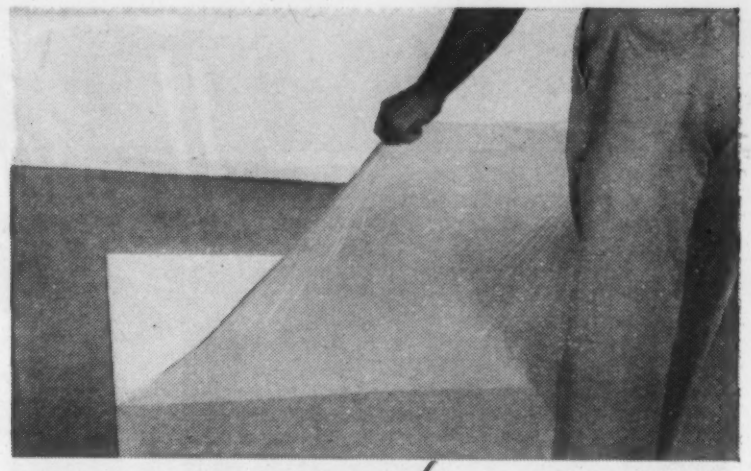
Their process involves a sintering —or firing—of the oxides, somewhat similar to that used in making clay pottery. However, much higher temperatures are required. They are able to produce the crucibles at a reasonable cost, but it would be too expensive for commercial adaptation as a substitute for household china.

Drs. Ryschkewitsch and Strott have extended their process to the making of crucibles of sintered ruby, zircon and beryllia (a main constituent of emerald) powders. Thoria, a radioactive material that has the highest melting point of all refractory oxides, is also used in the continuing studies.

Creep of High-Purity Aluminum

Recent investigations by William D. Jenkins of the National Bureau of Standards have led to significant fundamental information on high-

Adhesives eliminate rivets in attaching automobile clutch facings. This eliminates slow and costly riveting operations and reduces the danger of damage from rivets. This 3M adhesive application decreased the number of rejects.



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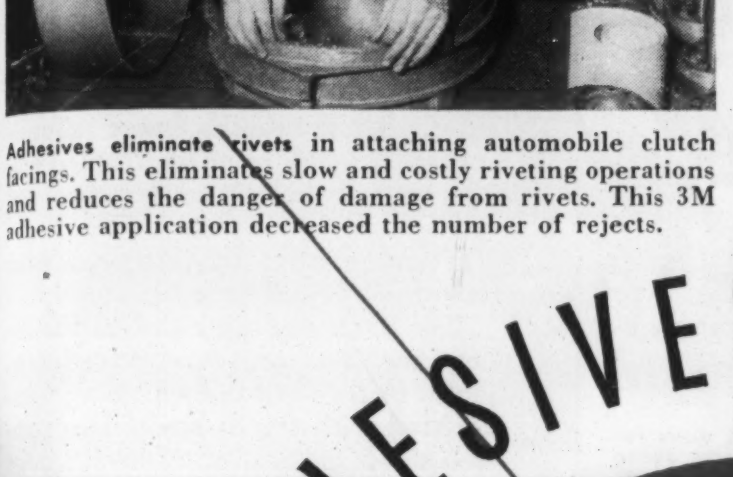

Sealers for Integral Fuel Tanks serve both military and commercial aircraft. This application of a 3M adhesive makes possible the sealing of wing compartments to serve as fuel tanks, rather than using separate fuel cells which are heavier and more costly.

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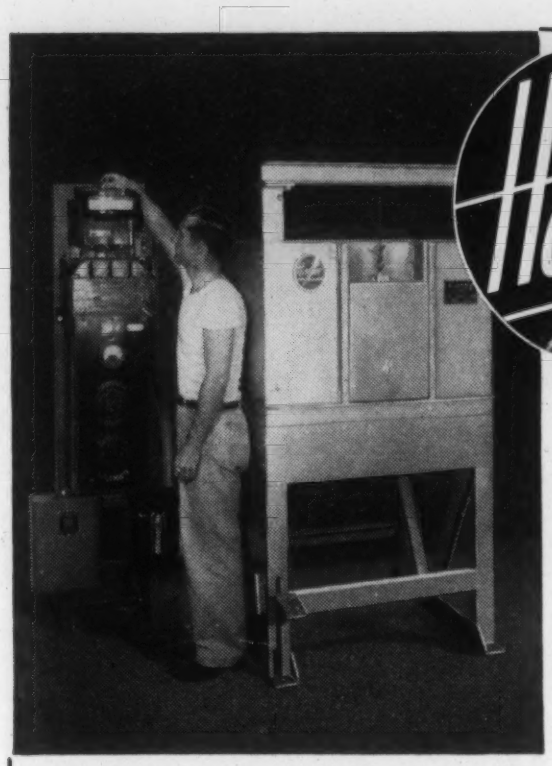

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Model HOU-9715-M-26 for annealing fused quartz parts. Photo Courtesy P. R. Mallory Co., Inc.

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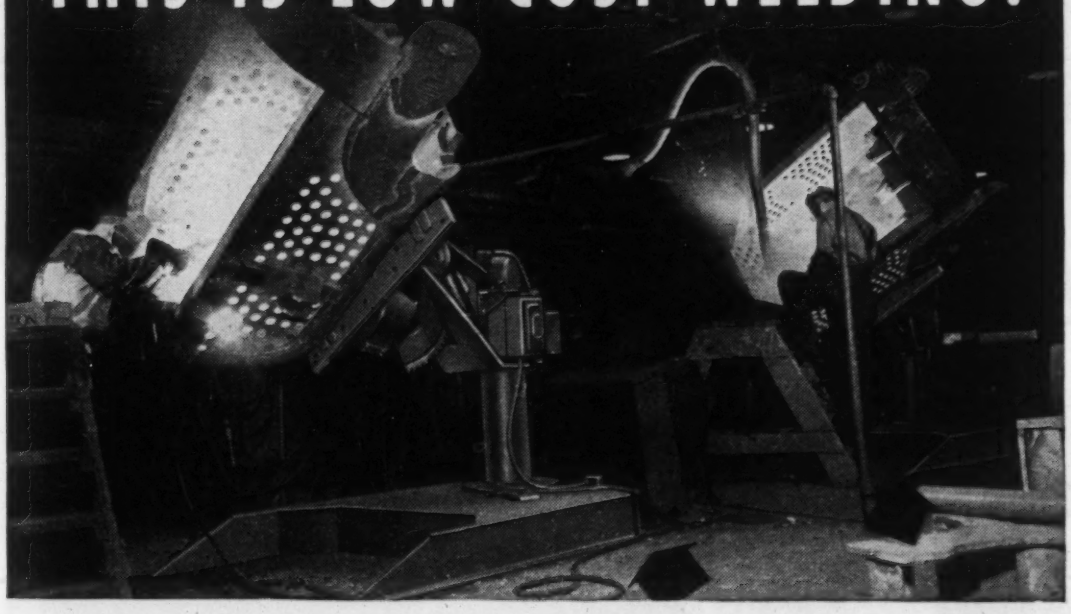

When a touch on a button moves weldments like these into the correct, most convenient position for a downhand pass, you get more arc time, more welding at lower cost. C-F power operated Positioners rotate the work in a full circle at any point in a range of 135° from the horizontal—giving welders a choice of an infinite number of downhand welding positions instantly.

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purity aluminum—specifically, the effects of stress and sudden changes of temperature on creep behavior.

The Bureau's study included the standard creep tests made in tension at 105 F under constant load conditions. These results were supplemented by data from interrupted tensile tests at room temperature and from other creep tests in which the test temperature was changed from 105 to 95 F, and back to 105 F.

The extension-time curves for the constant load tests conformed generally to the well-known patterns associated with creep; an initial extension upon application of load, a stage of decreasing rate of extension, a stage of minimum rate of extension and a stage of increasing rate eventually leading to complete fracture. However, as was observed in previous investigations of ingot iron and copper at the Bureau, the rate of change of extension with time in these tests occurred in a discontinuous manner. The frequency and amplitude of the cycles produced are attributed to the magnitude of the stress and the thermal-mechanical history of the material. Discontinuous flow was also revealed at room temperature by serrated stress-strain curves.

A linear relationship between tensile creep stress and second stage creep rate was not found. Rather, a sigmoidal curve was produced when these values were plotted on either a log-log or semi-log basis. Extrapolations based on a linear relationship could therefore result in serious difficulties.

Several types of recovery (grain softening) were revealed by the different tests. One type was manifested by an increase in extension at the beginning of the third stage (the region after which the average creep rate continuously increases) for a specimen tested under constant load at 105 and 95 F, then at 105 F.

Another type of recovery was illustrated by interrupted tensile tests in which the specimen was deformed to a predetermined strain, followed by dropping the load to zero. The tensile test was then continued to a higher strain value and the above process was repeated. Lowering of yield stress as a measure of recovery was evidenced in all the latter cases.

Structural features accompanying plastic deformation indicated that the self-recovery process occurring within

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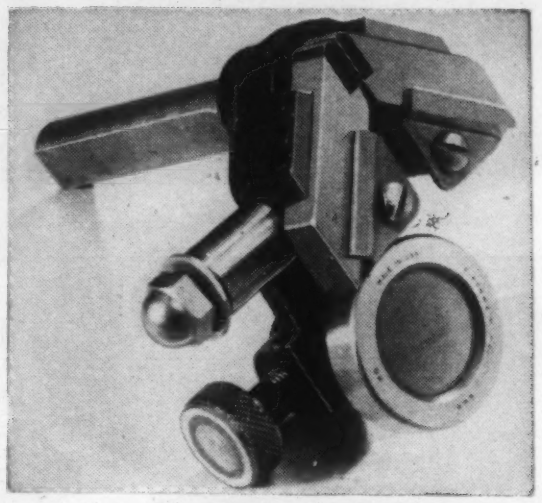

Keeps saws in line months longer!

Saw guides on saw setting machines took a terrific beating, resulting in costly downtime and maintenance. One saw manufacturer corrected this by wear-proofing the guide jaws with Carboloy Standard Blanks. Results: little or no downtime or maintenance!

Socket life increased 10 times!

Socket wrenches, used for driving hardened self-tapping screws, wore rapidly and slipped off the screw head, marring the product. The J. H. Williams Co. corrected this by using inserts of Carboloy cemented carbide. Life is increased at least 10 times over all-steel sockets; product scrap is greatly reduced.

Extra-accurate extra thousands of times!

Carboloy cemented carbide discs on the measuring faces of micrometers give greater accuracy, longer life. Scrap in the finished product is held down; frequent rechecking and refacing is eliminated.

WHAT better time to wear-proof with Carboloy cemented carbide than today, when machine and material conservation is so important?

Case history after case history proves that wear-resistant Carboloy cemented carbides combat wear, improve quality and increase the life of machine parts and products . . . increase it as much as 100 times in some cases!

Get your equipment rolling and keep it rolling for defense and essential civilian production. Wear-proof with Carboloy cemented carbide. Write, wire or phone:

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News Digest

the individual grains was continuously changing throughout each test. Deformation in different grains was characterized by difference in the magnitude and distribution of subcrystals and strain markings. Specimens strained at relatively fast rates showed a tendency to fracture in a transcrystalline manner. The cracks that eventually link up to form the main fracture course are initiated in the vicinity of the axis and propagate to the surface. In this way a "rim" is formed whose diameter decreases with increase in strain for any one particular specimen. Increases in creep rate tend to accentuate the formation of the rim.

New England Regional Conference, AIME

The fifth annual New England Regional Conference of the Institute of Metals Div., AIME was held at the Hotel Taft in New Haven early in April. A number of papers were heard and visits were arranged for the delegates to the Geometric Tool Co., Div. of Greenfield Tap & Die Corp., the Greist Manufacturing Co., and the Hammond Laboratory of Yale University.

A practical session was held on Friday afternoon. Arthur W. Young, Bridgeport Brass Co., Bridgeport, presented a paper on "Spectrographic Control Testing in the Brass Mill;" C. K. Stewart, International Nickel Co., Inc., New York City, entered a paper on "Embrittling Factors in Heat Treated Steels;" and A. S. Burgoyne, Pratt & Whitney Div., Niles-Bement-Pont Corp., West Hartford, spoke on "New Gaging Techniques for Metal Rolling Operations." The meeting was held on an off-the-record basis and the discussion of the papers was lively.

Dr. Bruce Old, vice-president, Arthur D. Little, Inc., Cambridge, Mass., was toastmaster for the banquet. A. N. Winchell was presented with the AIME Legion of Honor Pin in recognition of his 50th year as a member of AIME. Speakers were Tom Lyon, director of Supply Div., Defense Materials Administration, and Rear Admiral R. M. Watt, Assistant Chief and Director, Produc-

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It takes a lot of stopping to halt 70 tons moving at a speed of 100 miles per hour. Consequently, aircraft brakes must be tough. Among the toughest is the hydraulic disc brake. Basically, the disc brake is composed of two sets of discs, one of which is locked to the brake chassis and is non-rotating. The second set rotates with the wheel. The rotating discs are alternated with the non-rotating discs. When pressure is applied, the discs are compressed together. The friction results in braking action.

The steel used in the brake discs must withstand tremendous abrasive action even when they get hot. One brake manufacturer finds his best steel to be Sharon carbon strip steel. It resists friction wear at high heats and doubles the life of the brake.

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. . . that is the way Snap-on Tools come out of HEVI DUTY FURNACES"

says Verle Ericksen, Superintendent of Metallurgy.

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. . . with detachable handle. The choice of better mechanics everywhere for the hardest kind of nut-turning.

Snap-on Tools Corp. uses a Hevi Duty Vertical Retort Furnace for dry cyaniding and carburizing. Results indicate that even the long-handled tools come out of the heat in such excellent condition that there is no need of straightening or cleaning.

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tion Policy Div., Office of Naval Materials, Dept. of the Navy. Admiral Watt outlined the present shortages of strategic materials, stressing the necessity of keeping our sea lanes open for importing the many materials not available domestically. Mr. Lyons took the domestic side of the materials program, pointing out that our mineral industry, although a basic one, was small and would have to be increased rapidly to keep up with the material demand. Substitutes for many materials will have to be developed. In the interest of national security, neither speaker could elaborate on any of the points presented.

At the last conference session, a technical session, papers were presented on "Phase Contract Metallography", by George L. Kehl, Columbia University; "Electron Metallography", by R. D. Heidenreich, Bell Telephone Research Laboratories; and "Recent Developments in X-Ray Methods for Texture Determination", by Dr. Paul Beck, Notre Dame University.

John A. Swift, Swift Industrial Chemical Co., was chairman for the conference; Albert I. Blank, Chase Brass & Copper Co., was vice-chairman; Dr. Michael B. Bever, Massachusetts Institute of Technology, was secretary, and Dr. George P. Swift, treasurer. At a meeting following the close of the conference, Albert I. Blank was elected chairman of the Sixth Annual Conference, to be held in Boston in 1952.

Army Announces New Coating for Magnesium

The Army Ordnance Corps has announced recently the discovery of a new finish for magnesium and magnesium alloys. The finish is known as HAE, in honor of its discoverer, H. A. Evangelides, an electro-chemist at the Pittman Dunn Laboratory at Frankford Arsenal. The discovery was made, incidentally, by Mr. Evangelides while working on a project assigned to Frankford Arsenal by the Materials Section, Office Chief of Ordnance, to determine performance limits of the various magnesium coatings for Ordnance applications.

The outstanding characteristics of HAE are its excellent corrosion re-

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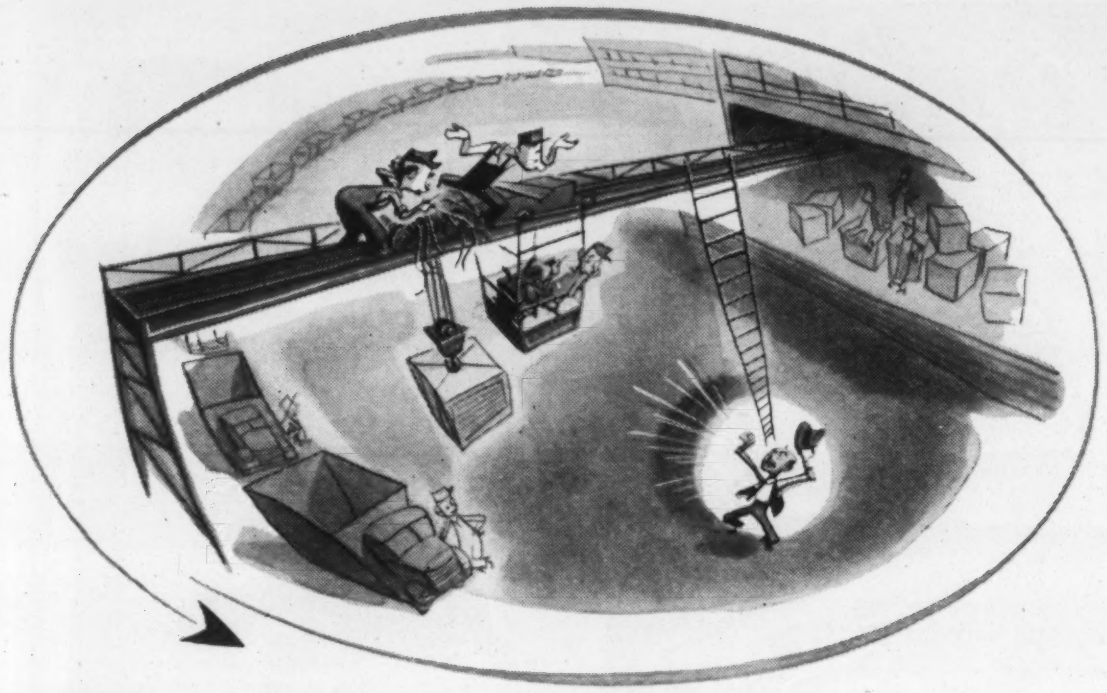

Burned-out Motors Waste Manpower!

Men without motors are just about as helpless in a modern factory as a wagon without wheels on a superhighway.

In many plants the failure of a single motor used to drive an overhead crane or a conveyor system can cost thousands of dollars an hour in lost production and wasted man-hours of labor.

The answer is Class H insulation made with Dow Corning Silicones. In a steel mill, for example, a cupola crane hoist motor insulated with the best Class B materials had an average life of only 50 days. Rewind costs alone amounted to $3,634 in three years. That motor, rewound with Class H Insulation at an extra cost of only $79 was still in good condition after 613 days on the hoist and 908 days on the trolley bridge.

And Class H is readily available. Most of the best rewind shops now feature this longer lasting, more reliable class of insulation. Leading motor manufacturers are quoting price and delivery on new Class H machines.

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News Digest

sistance, high melting point, good dielectric strength and hardness. It has a normally brown color of varying shades, and is an excellent paint base in itself.

HAE can be applied to any of the commercial magnesium alloys, wrought or cast, including the magnesium-zinc-zirconium alloy ZK-60. It is applied electrolytically, much the same as aluminium alloys are anodized. The electrolyte is compatible with magnesium. In other words, it is safe to apply the coating to magnesium castings without danger of having the metal corroded by entrapped electrolyte.

Probably the field in which this coating will produce the most revolutionary applications of magnesium are those where corrosion resistance has been a limiting factor. HAE-coated J-1 panels show no corrosion up to 90-hr exposure in salt spray tests and no corrosion up to 4500-hr exposure in salt spray tests when the coated surface is waxed.

Abrasion tests, using the Taber Abraser with CS17 wheel and the 1000-gram weight, produced no breakdown of the HAE coating after 8000 cycles. By comparison, specimens having dichromate, alkaline dichromate, and galvanic anodize treatments showed a breakdown after 5 cycles. These latter treatments are not intended to increase the abrasion resistance and hardness of magnesium, but the comparative figures of 5 cycles and 8000 cycles indicate the hardness of HAE.

HAE provides magnesium with a surface that is resistant to temperatures above 2500 F. If a panel of HAE-treated magnesium is held vertically and subjected to the flame of two Fisher blast burners, the magnesium will melt locally and form a bulge, but the coating will not be impaired. The flexibility of the coating is sufficient to take a considerable bulge without cracking.

The strength and modulus of elasticity of HAE are not yet known. A 0.022-in. thick specimen of magnesium loses about 8% of its tensile strength after a 1½ hr treatment. This loss in tensile strength is proportional approximately to the thickness build-up (see above) of the treated specimen, *i.e.*, approximately 80% of the total coating thickness. However, as the thickness of the

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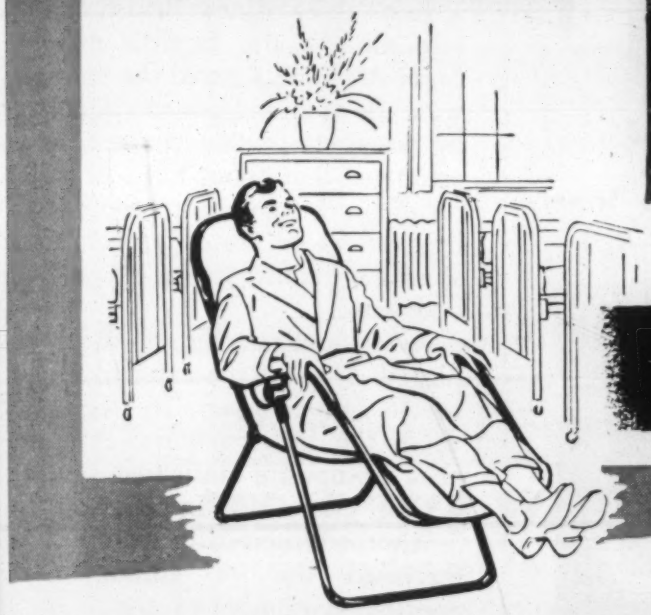
FOR THE MANUFACTURER...



FOR THE PATIENT...

HOSPITAL PATIENTS can relax in every position, from full-reclining to upright, in this sturdy rejuvenating chair made by Barcalo Manufacturing Company. Steel tubing provides the stiffness and rigidity to make the chair steady and reassuring to the patient, yet light to move.

The manufacturer likes the way ELECTRUNITE Steel Tubing works on this application. Uniform ductility and wall thickness assure rapid, predictable forming and bending of the tubes to shape. Where tube ends must be fully flattened at joints, there's no trouble with cracks and fractures. The excellent surface of this ELECTRUNITE Tubing requires no special handling or trick treatments to hold long-lasting finishes under severe service.

Have you considered using ELECTRUNITE Steel Tubing in your essential products, such as these invalid chairs? We'll be glad to discuss your problems . . . and offer you the benefits of Republic's 3-Dimension Metallurgical Service. It's the helpful service that focuses the knowledge and experience of field, mill, and laboratory metallurgists on your fabrication problems.

REPUBLIC STEEL CORPORATION
STEEL & TUBES DIVISION
224 EAST 131st STREET
CLEVELAND 8, OHIO

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REPUBLIC STEEL ®
ELECTRUNITE TUBING

TESTED IS TRUSTED

To Test WIRE, for Inspection and Production Control

SIGNAL CORPS WIRE

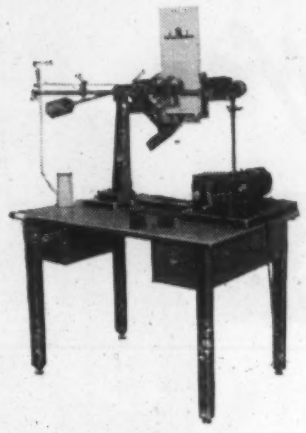
X-5 for Tensile of Individual Components

XL for Tensile of Jacket

R for Cutting Resistance of Jacket

RADIOGRAPHIC WIRE IP-2

Exclusive Inactive-plane Tester, tests from finest wires to 2,000 grams tensile



REQUEST CATALOG 50

SCOTT TESTERS, INC.

65 Blackstone Street
Providence, R. I.

Scott Testers — Standard of the World

Better Forgings

AT LOWER COST WITH

Ajax-Northrup Induction Heating

PINION BLANKS

Production: 300 per hr.
Stock: 1½ in. diam. bars, 12¼ to 14 in. long.
Heated by: Bank of five induction heaters at 400 kw.

Steel savings made possible by scale-free Ajax-Northrup induction heat . . . longer die-life due to lack of scale . . . fewer rejects . . . and reduced machining costs because of closer forging tolerances add up to better forgings at lower cost for these pinion blanks.

Ajax-Northrup forging heaters take little floor space, can be spotted right in the production line, are easily adapted to conveyorized production. No start-up time, no re-handling of heated billets during temporary shut-downs. Heat any part or all of the billet with accurate temperature control. Shops are cooler, cleaner, quieter. Send for our technical bulletins today!

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AJAX ENGINEERING CORPORATION

AJAX NORTHRUP

131

HEATING & MELTING

News Digest

specimen increases, the percentage loss in tensile strength will diminish.

HAE is available, at present, for military applications only. Further information about HAE, if required for any agency of Department of Defense, may be obtained through that agency from the Office Chief of Ordnance, Washington 25, D. C., Attention: ORDTB—Materials.

British Automobiles Heavy on Light Metals

In a survey of new British automobile models, the English magazine *Light Metals* has noted the extremely wide use of aluminum and light alloys by designers in that country. It was estimated that about 80% of the vehicles use a significant proportion of light alloys or are of predominantly aluminum construction, especially in bodywork.

Aluminum panelling is widely employed. Most of the external sections are 18 swg, although 16 swg is used where the design requires extra stiffness. Composite laminated panelling is used, particularly in motor coaches.

Another interesting feature is the increased use of aluminum-alloy flooring. A number of approaches to this type of assembly have been developed. Several companies patented forms consisting of extruded sections about 6 to 8 in. wide. Some of them depend upon the inter-locking of the adjacent extrusions and others on the use of special clips.

Such methods of floor construction usually eliminate drilling of the plate prior to securing with more conventional fastenings, such as bolts or rivets. Chequer plate flooring is also in evidence, used on such widely varying vehicles as fire-engines, coaches and commercial vans.

The use of light-alloy extruded sections for the main body framework is fairly widespread. In general, the alloys used are of the magnesium-silicide or the Duraluminum types. A few light-alloy chassisless vehicles have even been developed.

Steel framework is used in conjunction with light metal panelling in some designs, and aluminum cover strips and molding are popular. Several aluminum bumpers are also in use. These are fabricated from formed sections which are subsequently

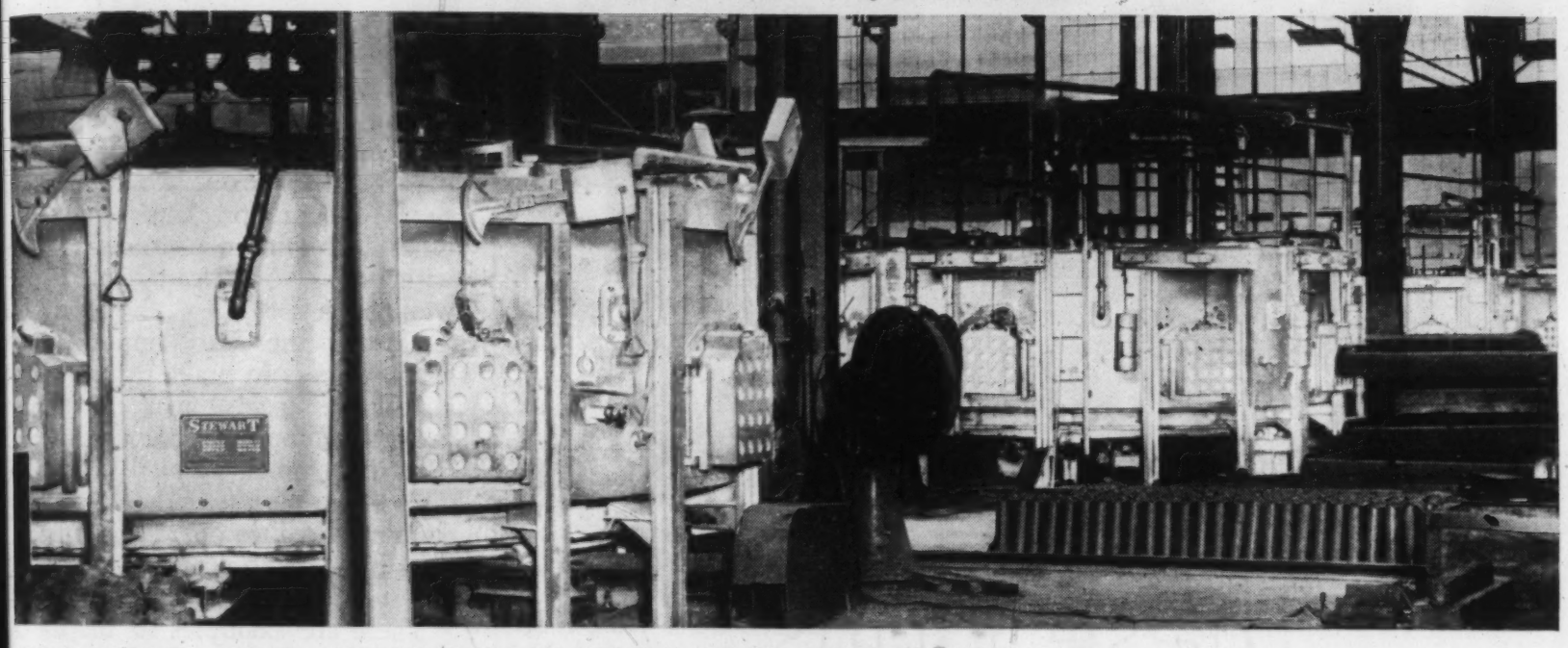
No. 107 of a Series of Typical Installations

Sunbeam STEWART

THE BEST INDUSTRIAL FURNACES MADE

HOW SUNBEAM STEWART FURNACES MEET THE DEMANDS ON THE PRODUCTION FRONT

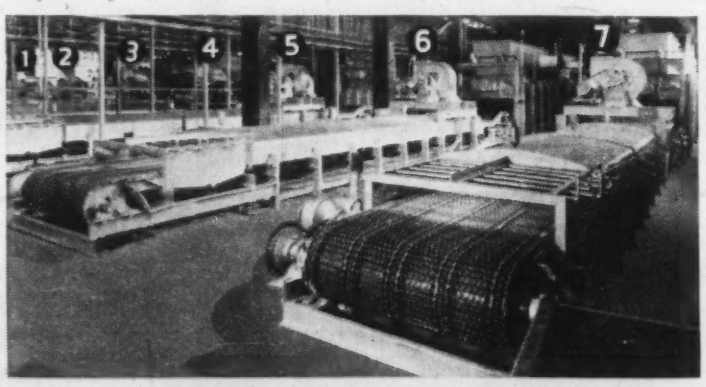
DEFENSE REQUIREMENTS CAN BE MET QUICKLY WITH PROVEN SUNBEAM STEWART HEAT TREATING EQUIPMENT



HEATING PROJECTILE BILLETS FOR FORGING—Three of nine Sunbeam Stewart Rotary Hearth Furnaces that met the demand for fast, uniform production during World War II are shown above. This installation is typical of the Sunbeam Stewart units designed to meet the defense requirements of the present emergency.

Sunbeam Stewart's circular-tunnel rotary hearth design, sand-sealed and friction-driven at three points has been proven by years of heavy-duty, 24-hour-a-day operation. Multizone control plus the sand-seal feature guarantees the thorough, even heat good forging practice requires with scale problem reduced to a minimum.

Sunbeam Stewart Engineers have developed both Rotary Hearth and Pusher-type Forging Furnaces. Both designs feature simplicity of operation and the ability to heat quickly with even heat distribution and close temperature control.



SHELL LINE HEAT TREATING. Seven of these complete Sunbeam Stewart Shell Lines shown at right were used in one leading plant during World War II. From the time shells were loaded in the Hardening furnace until they were taken from the cooling chamber conveyor belt, all processes were completely automatic—reducing man power required and insuring proper temperatures and cycle. When the shells emerged, they were ready for shot blasting and final machining operations. Sunbeam Stewart designed and installed many similar lines.

IF YOU ARE CONSIDERING DEFENSE WORK CALL SUNBEAM STEWART. Designs are available for heat treating the following materiel:

SHELLS: 57MM; 75MM; 90MM; 105MM; 120MM; 155MM; 3", 5", 6", 8" Navy Shells (Harden, Quench and Draw).

FORGINGS: Rotary Hearth and Pusher-type Forging Furnaces.

ARMOR PIERCING SHOT (Harden, Quench and Draw).

CARTRIDGE CASES (Anneal, Stress Relieve).

MACHINE GUN CLIPS (Harden, Quench and Draw).

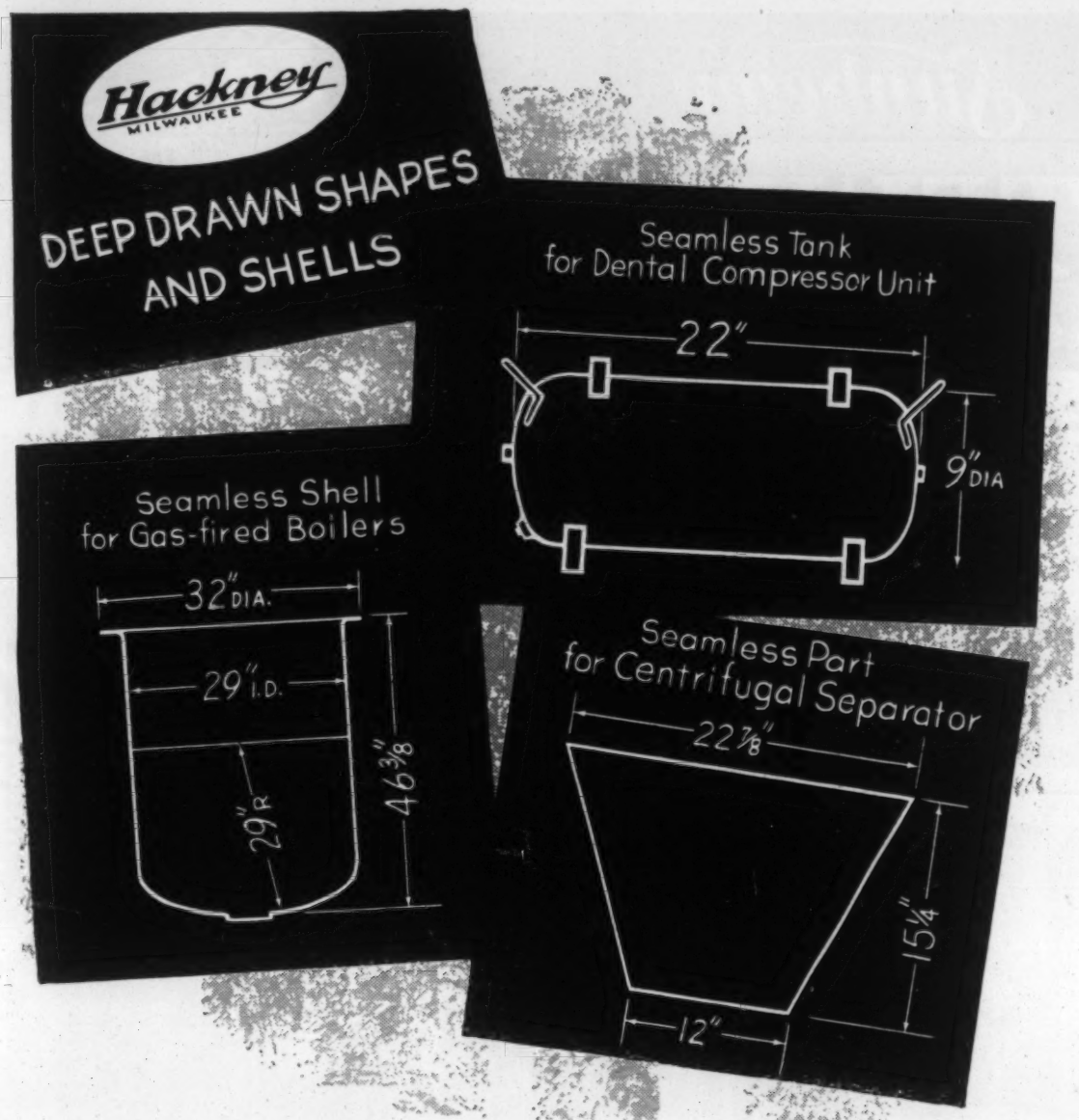
Sunbeam STEWART **INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION**

(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 111, 4433 W. Ogden Ave., Chicago 23—*New York Office:* 322 W. 48th St., New York 19—*Detroit Office:* 3049 E. Grand Blvd., Detroit

Canada Factory: 321 Weston Rd., So., Toronto 9

A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.



These Plans
may figure in your future

You and your product may share a better future when a Hackney Deep Drawn Part replaces a casting or forging in your product.

The Hackney Deep Drawing Process assures stronger shapes and shells because they're shaped under pressure from one piece of sheet metal . . . lighter weight parts because cold drawn metal does the work of heavy forgings and castings . . . and they're faster to produce because time-consuming machining and welding operations are eliminated.

Pressed Steel Tank Company, manufacturer of Hackney Products, has almost 50 years of specialized experience in deep drawing shapes and shells for many manufacturers in many industries. These Hackney Products are made in a wide variety of metals and alloys . . . in a capacity range from 1 quart to 110 gallons . . . inside diameters from approximately 3 inches to 32 inches.

See if Hackney engineers can help you adapt special shapes to improve existing products or to develop new products. Send us a drawing of your requirements today.

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PRESSED STEEL TANK COMPANY
Manufacturer of Hackney Products

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936 W. Peachtree St., N.W., Room 111, Atlanta 3
208 S. LaSalle St., Room 788, Chicago 4 • 559 Roosevelt Bldg., Los Angeles 14

CONTAINERS FOR GASES, LIQUIDS AND SOLIDS

News Digest

polished. Some small fittings, like handrails, window frames and accessories, were of light alloys.

Magnesium castings are established for such applications as crankcases and gear boxes, although there is no use of magnesium sheet or sections as yet. Several British companies are investigating the possibilities.

Greater use of the light alloys is made in the high-priced field, although the mass-produced, cheaper cars are also taking advantage of die casting, which has proved competitive with malleable iron for components like steering boxes, worm castings, engine-mount brackets and door hinges. Aluminum pistons, with and without anodic treatment, are in widespread use.

One of the most important developments is in brake drums, where a steel liner is molecularly bonded to a cast aluminum drum. This is particularly advantageous on high-speed cars, where the thermal properties of aluminum reduce operating temperatures by 90 F, to give less brake fade and reduced wear on linings.

There are examples of the use of aluminum connecting rods on cars in classes apart from truly racing types. It is usual to run the gudgeon pin directly in the alloy forging. Although in the past experiments have been made with the rod as a plain big-end bearing, it is general practice on production types to provide a steel-backed liner.

Glass and Ceramics Soldered to Metal

General Electric Co. engineers can solder glass to metal in a process which makes a bond stronger than the glass itself.

The method, which can also be used to solder metal to ceramics and carbon, was originated by scientists of the G-E Research Laboratory, and is currently being tested for industrial applications by the Company's General Engineering Laboratory.

The glass and metal areas to be soldered are painted with a thin layer of titanium hydride, and solder is placed upon both painted areas. The parts are placed together and then heated under a vacuum.

When the temperature reaches

HIT BY LACK OF TIME AND PARTS?

OILITE Finished Machine Parts give you these important advantages:

- **Quick delivery**
- **No tooling program**
- **Low price**
- **Release of skilled manpower**
- **Conservation of strategic materials**

ALTERNATE MATERIAL
Oilite gives you a dependable alternate for bronze, brass, aluminum, cast iron, steel, and plastics.

MACHINING ELIMINATED
Oilite processes help you eliminate as many as twenty-four machining operations.

SIMPLE TOOLING
Oilite products require little tooling; saving you floor space, jigs and fixtures, skilled manpower, and time.

UNDUPLICATED EXPERIENCE
Oilite engineers pioneered iron powder metallurgy; their experience of more than twenty years, and Oilite's broad facilities are at your disposal.

OILITE FERROUS-BASE BEARINGS
Heavy duty, oil-cushion, self-lubricating.
Excellent for replacing your nonferrous units of solid material.

Oilite representatives and field engineers are located throughout the U. S. and Canada. You are invited to contact the field engineer in your district or write the home office.

AMPLEX MANUFACTURING COMPANY
Subsidiary of Chrysler Corporation
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Besides Field Engineers, Supply Depots, too, are maintained in Principal U. S. and Canadian Cities.

A Note to Executives

Some facts about Oilite Products

Essentially, Oilite metal powder products constitute a new series of metals—each formulated to do a specific job. When used as replacements for tin, aluminum, copper, and other strategic materials, they often become permanent replacements.

For example, on any unit where motion occurs, Oilite provides the otherwise unobtainable feature of self-lubrication.

As with any other new material, habitual specifications should often be reviewed when considering Oilite finished machine parts. To illustrate, designers using cold rolled steel, may automatically apply the strength specifications of that material. The engineer, however, knows that strength as low as 40% of steel is satisfactory.

Another advantage of Oilite is its broad range of physical properties. Thus, when high stresses exist, Oilite engineers specify the correct material necessary to meet the requirements.

When production, including mass quantities, must be reached in record time, Oilite bearings and finished machine parts may provide you with an excellent reservoir.

A. L. Langhammer
President

OILITE
PRODUCTS

OILITE PRODUCTS:
Heavy duty, oil-cushioned, self-lubricating bearings and finished machine parts in ferrous and nonferrous metals and alloys. Permanent filters. Friction units. Self-lubricating cored and bar stock.

made of

Rigidized
DESIGN STRENGTHENED Metals

Full size photograph of
RIGIDIZED METAL
Pattern 6-WL

When Hotpoint, Inc. installed RIGIDIZED METAL decking in their commercial ovens in place of conventional decking, maintenance costs were greatly reduced. This durable metal does not have the susceptibility to damaging heat warpage. RIGIDIZED METAL oven flooring prevents burned-bottom baked goods because of the easy passage of air along the 3-DIMENSIONAL patterns. Baking heat is reached faster than is possible with conventional flooring.

The 3-DIMENSIONAL design-strengthened qualities of this modern metal are applicable to products in every industrial and commercial field. RIGIDIZED METAL makes possible lighter weight with added strength, CONSERVATION OF CRITICAL MATERIAL, surface protection and longer life, *PLUS* eye-sales appeal. In use today in buildings, trains, planes and many other applications, there is a RIGIDIZED METAL that will give your product added value.

Investigate these possibilities!

Send for your copy of the
Rigidized Metals IDEA Handbook
TODAY

Rigidized Metals Corporation

660 OHIO STREET, BUFFALO, N. Y.

News Digest

about 900 F, the titanium hydride decomposes. This causes the solder, which has already become molten, to adhere to the titanium-painted areas of both glass and metal. A strong, tight bond is formed upon cooling.

By using soft metal solders, it is possible to subject this glass-to-metal seal to rapid temperature changes without danger of cracking, despite the wide difference in temperature expansions between glass and metal. This is possible because the differences in movement are absorbed by the solder.

The new technique is now in use in aircraft ignition systems, and laboratory investigations have suggested possible applications in the manufacture of transformers, capacitors and electric motors. These possibilities are now under consideration, according to laboratory engineers.

Early work on the process was done by Floyd C. Kelley and Ralph J. Bondley, of the G-E Research Laboratory, and some of the present investigations are being conducted by Lawrence J. Hogue, of the General Engineering Laboratory.

News of Engineers

General Electric Co. has announced various changes of personnel within its numerous departments. *L. T. Callahan*, formerly manager of the Lynn, Mass., Assembly Div., was named manager of operations of the Aircraft Gas Turbine Div. In the Welding Dept., *W. G. Arnold* became manager of manufacturing, relinquishing his previous position as manager of the Fitchburg Works. *Robert R. Person*, manager of sales for the Apparatus Dept.'s Special Products Div., was promoted to staff assistant to the manager of manufacturing of the Large Apparatus Div. Concurrently, Mr. Person was appointed secretary of the Division's Appropriation Committee. *Elmer F. Paul* succeeds *William F. Oswalt* as manager of manufacturing of the Specialty Transformer & Ballast Div. Mr. Oswalt was promoted to the position of assistant manager of manufacturing of the Control Div. *Carl L. Ipsen*, manager of the Industrial Heating Div., has relinquished his duties to accept a position in an advisory capacity to the Machinery Div. of the National Production Authority. In his absence, Mr. Ipsen's responsibili-

PROBLEM:

How to Get "Aluminum-to-Aluminum" Connections in the Termination of Aluminum Conductors

GENERAL PLATE:

Provided the Solution with the Composite Metal ALCUPLATE*

Aircraft manufacturers and power companies were troubled with the electrolytic action which took place when aluminum main line cables were joined to copper branch lines. To overcome this problem it was necessary to have aluminum-to-aluminum or copper-to-copper connections.

General Plate engineers solved the problem with *Alcuplate* (aluminum clad to copper) which gives like metal connections, thus overcoming the corrosion objections. Alcuplate is widely used in the electrical field for clips, shims, bushings, terminals, etc. Enclosures for sealed devices can be spun or drawn from *Alcuplate* and the copper surface makes soft soldering easy.

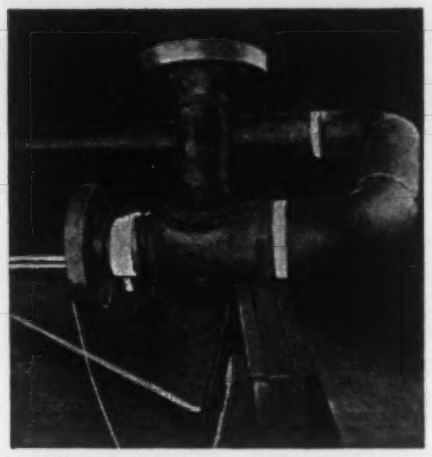
Alcuplate is available in sheet, strip or seamless tubing.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals or base to base metals can overcome your problems . . . often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy. Write for information. *Reg. U. S. Pat. Off.

Have You a Composite Metal Problem?
General Plate can solve it for you

GENERAL PLATE
Division of Metals & Controls Corporation
606 FOREST STREET, ATTLEBORO, MASS.



THIS PHOTO shows radium being used to take a radium-radiograph of a weld. Placing the radium centrally in the pipe and the film on the outside (held in place by white tape) permits radiographing the entire circumferential weld with one exposure.

Use

RADIUM

for the tough weld inspection jobs

because radium-radiographing equipment is

1. **Portable**
2. **Easily handled**
3. **No training needed to operate**
4. **Economical**

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For the same reasons that radium-radiography has won nearly universal acceptance in steel foundries throughout the country, it is becoming the preferred means of inspection in welding shops.

No capital investment is required to have radium-radiography available for the inspection of welds because the equipment may be rented or leased with economy.

Write today for case histories and additional information.

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RADIUM CHEMICAL CO., INC.

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News Digest

ties will be assumed by *E. W. Cunningham.* In the Chemical Dept., *K. O. William Sandberg,* industrial engineer for the Manufacturing Div., was promoted to the position of manager of the Industrial Engineering Section. And finally, *Thomas H. Way,* manager of GE's Taunton, Mass., plant, was named to the Manufacturing Div. staff at Pittsfield, Mass.

John Obrebski has joined The Monarch Machine Tool Co. in the capacity of metallurgist.

Federal Products Corp. has announced the election of officers for the organization. *L. C. Tingley* retired as president of the firm and became chairman of the board. *Fred C. Tanner* assumes the duties of president. Two new vice presidencies were created with the addition of *Herbert F. Joslin* as vice president, manufacturing, and *Thomas L. Johnson, Jr.,* as vice president, research and development. Also re-elected were *Leonard B. Colt,* vice president, sales; *Stephen B. Reynolds, Sr.,* secretary; and *Charles N. Kingsford,* treasurer.

Emory W. Worthington has joined the Bjorksten Research Laboratories, Inc., and will serve in the capacity of vice president in charge of mechanical development.

The Hays Corp. has promoted *Orval M. Riggs* from chief project engineer in the Sales Dept., to the position of manager, application engineering.

L. N. Anderson, vice president of The Commercial Cable Co., has been elected a vice president of All America Cables & Radio, Inc., and Mackay Radio & Telegraph Co.

Allegheny Ludlum Steel Corp. has appointed *Robert T. Eakin,* metallurgical engineer who joined the company as a student trainee in 1940, manager of the Brackenridge, Pa., plant. He succeeds *George Evans,* who becomes special consultant to the vice president in charge of operations.

Martin Kelly, director of industrial relations in Continental Motors Corp.'s Muskegon, Mich., plants, has been elected a vice president of the corporation.

Towmotor Corp. has announced the election of *Lester M. Sears* as chairman of the board of directors. *C. Edgar Smith,* executive vice president, succeeds Mr. Sears as president of the firm.

Three vice presidents have been appointed by Jefferson Chemical Co., Inc. They are *William H. Bowman, Max Neuhaus* and *L. P. Scoville.*

C. Jared Ingersoll was named a director of United States Steel Corp., to succeed *Walter S. Gifford,* who resigned following his appointment as American Ambassador to Great Britain. Another new director of the corporation, and a member of its Finance Committee, is *Herbert E. Smith,*

CE-111-A

LOOK AT THESE SAVINGS

53%...74% of noble metal thermocouple cost

WITH

ENGELHARD RECLAIMING PROCESS

ON ONE 30" long platinum thermocouple, the Engelhard Reclaiming Process saved 53% as compared to the cost of a new unit. On another, the saving was 74%. These are typical examples of how Engelhard Reclaiming — including application of scrap value of old noble metal thermoelements against cost —can stretch your equipment dollar. What's more, Engelhard restores old thermoelements to like-new condition . . . in just 48 hours, if necessary.

ENGELHARD also manufactures a line of wide-range thermocouples and accessories to meet your specific conditions of atmosphere and temperature. For complete information on either Repairs and Reclaiming or New Couples, fill out coupon below and mail today.

MAIL COUPON

Please send me:

☐ Data on Engelhard Reclaiming Process
☐ Free copy of Engelhard Bulletin 330-D

Name .....

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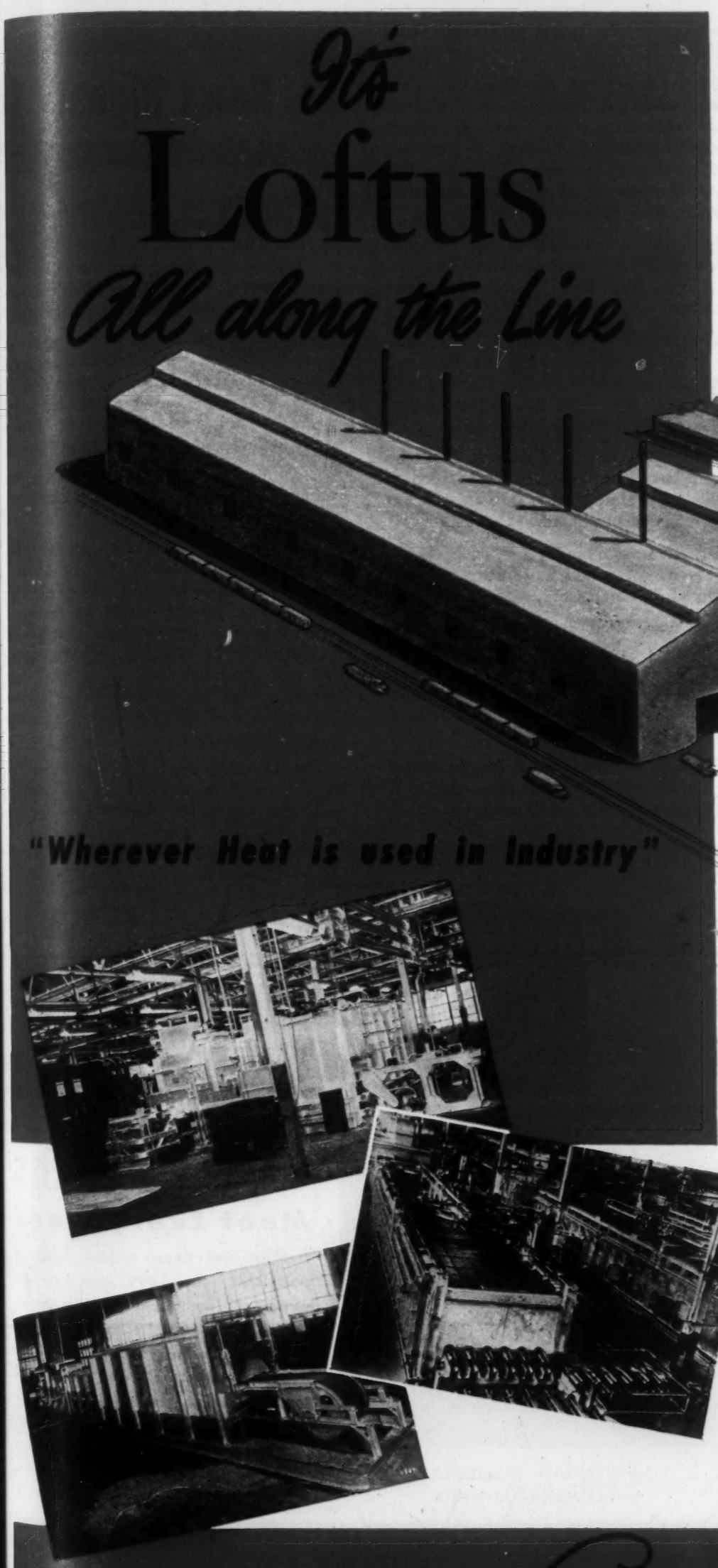
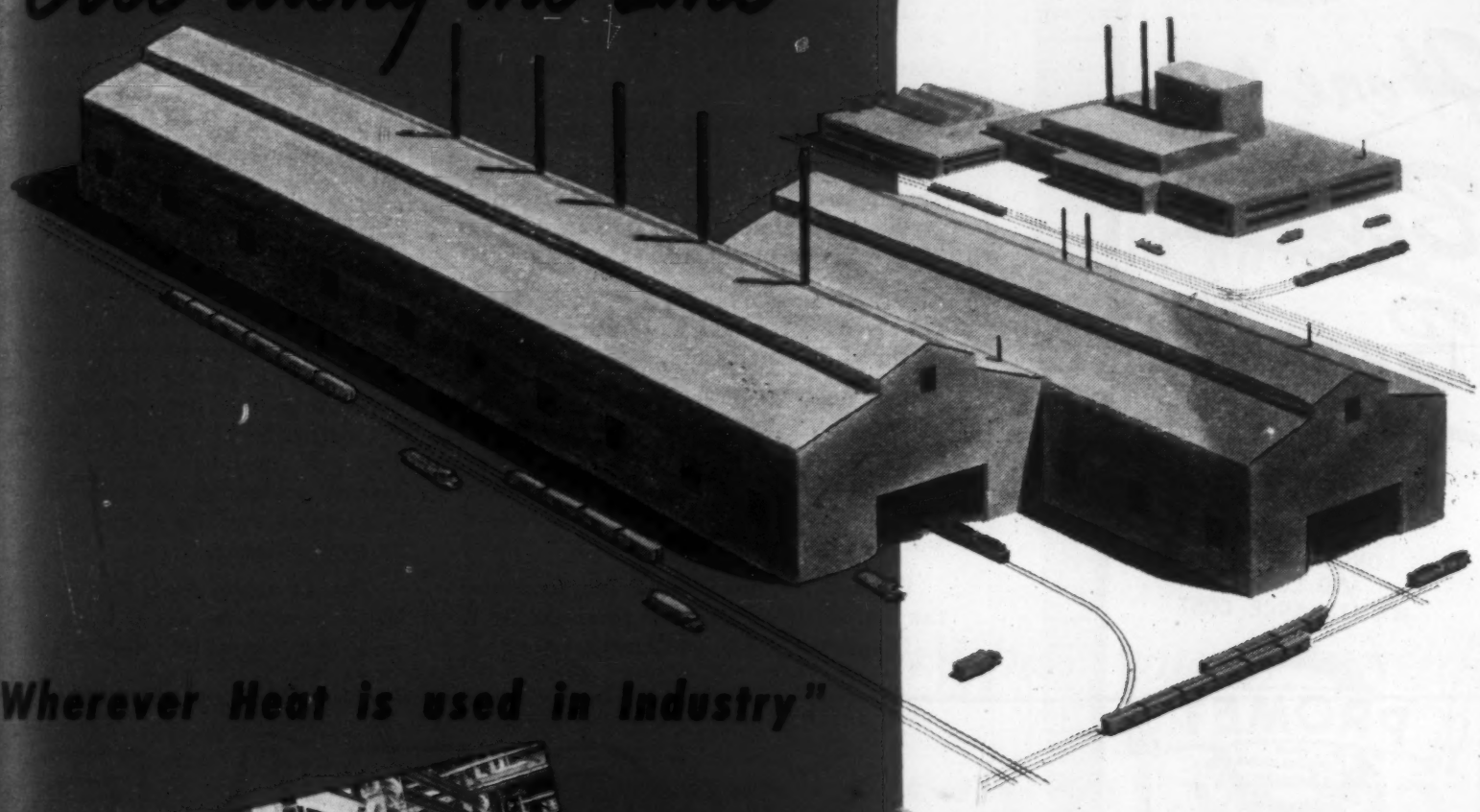
CHARLES ENGELHARD, INC.
850 PASSAIC AVENUE, EAST NEWARK, N. J.

It's Loftus All along the Line

"Wherever Heat is used in Industry"



For Complete Departments or Any Type of Heat Treating Furnace



Whether it is the designing and construction of a Complete Plant, a complete Heat Treating Line or a single unit, the Loftus organization, one of the largest in the country with *specialists* in all phases of industrial heating, is equipped to handle any commitment with skill and exactness—and with undivided responsibility.

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LOFTUS ENGINEERING *Corporation*

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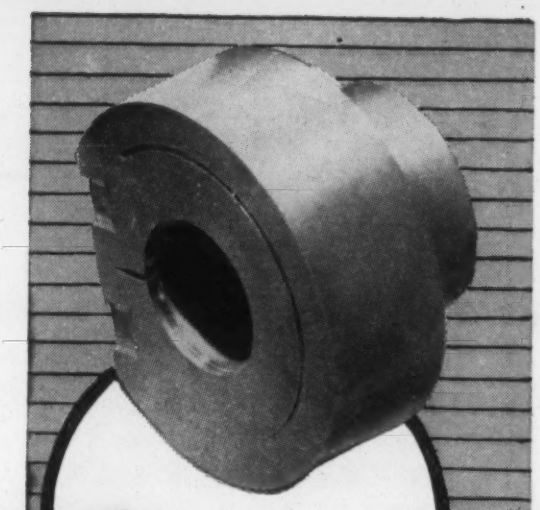
Designers and Builders Engineers, Consultants, Contractors



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with a MONEY-BACK GUARANTEE OF LONGER SERVICE AND LOWER MAINTENANCE COST

PROMET
THE Engineered BRONZE

BEARINGS
BUSHINGS
WEARING PARTS
Machined or rough cast.

American Crucible methods, experience, know-how, and equipment save you real money. Castings to your patterns—any size, shape or section up to 3,000 lbs. Pattern making, designing and machining.

PROMET BRONZE BAR STOCK

Round, solid, tubular. Rough cast or fully machined. Cored stock, all sizes (by 1/8" steps) from 1/2" minimum core to 26" O.D. 13" lengths or less. 6 grades of hardness.

Write for literature or send blueprints, conditions of operation and other data for quotations and recommendations as to alloys.

THE AMERICAN CRUCIBLE PRODUCTS CO.

1325 Oberlin Ave.
Lorain, Ohio,
U.S.A.

chairman of the board of United States Rubber Co.

New officers for the Electronic Tube Corp. have just been elected. They include: chairman of the board, *George B. Howell;* president, *Henry S. Bamford;* vice president, *Theodore T. Toole;* treasurer, *Matthew H. McCloskey;* and secretary, *J. Dress Pannell.*

J. F. Smith, manager of the Philadelphia branch of Whitehead Metal Products Co., Inc., has been appointed a vice president.

The retirement of *Ellis W. Test* after 43 years of service with the Pullman-Standard Car Manufacturing Co. has been announced. Mr. Test had served as assistant to the president since 1935.

All officers of the Link-Belt Co. who served last year were reelected recently. At the same time *Robert C. Becherer* was elected a vice president.

Dr. *Manson Benedict* has been chosen to serve as scientific director of the National Research Corp.

The Nice Ball Bearing Co. elevated *Theodore E. Spilker* to the position of vice president. He will retain the secretaryship of the company. Simultaneously, *John E. Mullen,* formerly plant manager, was also made a vice president.

William F. MacDonald has succeeded the late *G. W. Pressell* as president of E. F. Houghton & Co. of Canada, Ltd.

News Digest

The appointment of *William E. Harvey* as vice president in charge of production of carbon and graphite products has been announced by Speer Carbon Co. Mr. Harvey previously served as plant manager in charge of carbon and graphite products.

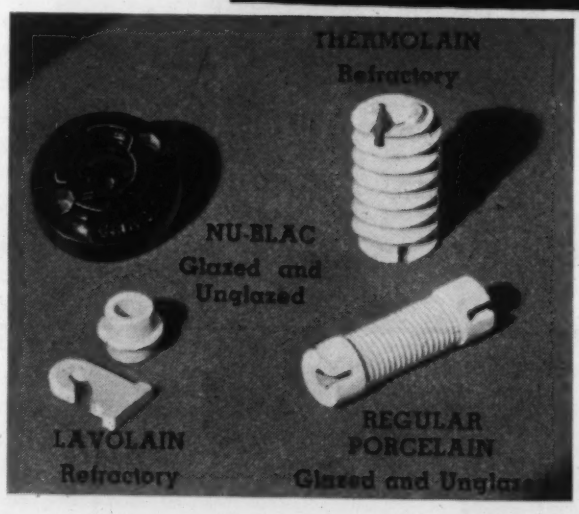
The board of directors of the Aro Equipment Corp. was increased from seven to nine members with the addition of *Ralph W. Morrison,* vice president, and *J. P. Johnson,* vice president in charge of the Cleveland Manufacturing Branch.

Clarence E. Stender, comptroller, was recently elected assistant secretary-treasurer of Pressed Steel Tank Co.

Dr. *John F. Thompson,* president of The International Nickel Co. of Canada, Ltd., was named to the additional office of chairman of the board of directors, succeeding the late *Robert C. Stanley.* Concurrently, Dr. *Paul D. Merica,* executive vice president and a director, was elected a member of both the Executive Committee and the Advisory Committee of the Company.

The Levinson Steel Co. has filled two major executive posts in the company with the naming of *Morton Chatkin* and

STAR



Also VITROLAIN, HUMIDOLAIN and COMMERCIAL WHITE

CERAMIC SPECIALTIES
Meet Every Need

STAR has been making electrical porcelains since 1899, and has been continually compounding new formulas to meet unusual specifications. The various grades and kinds shown here possess mechanical and dielectrical properties that are ideally suited to conditions of heat, moisture, chemicals, weathering agents and resistance to electricity.

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★ THERMOLAIN
★ VITROLAIN
★ NU-BLAC
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The STAR PORCELAIN COMPANY

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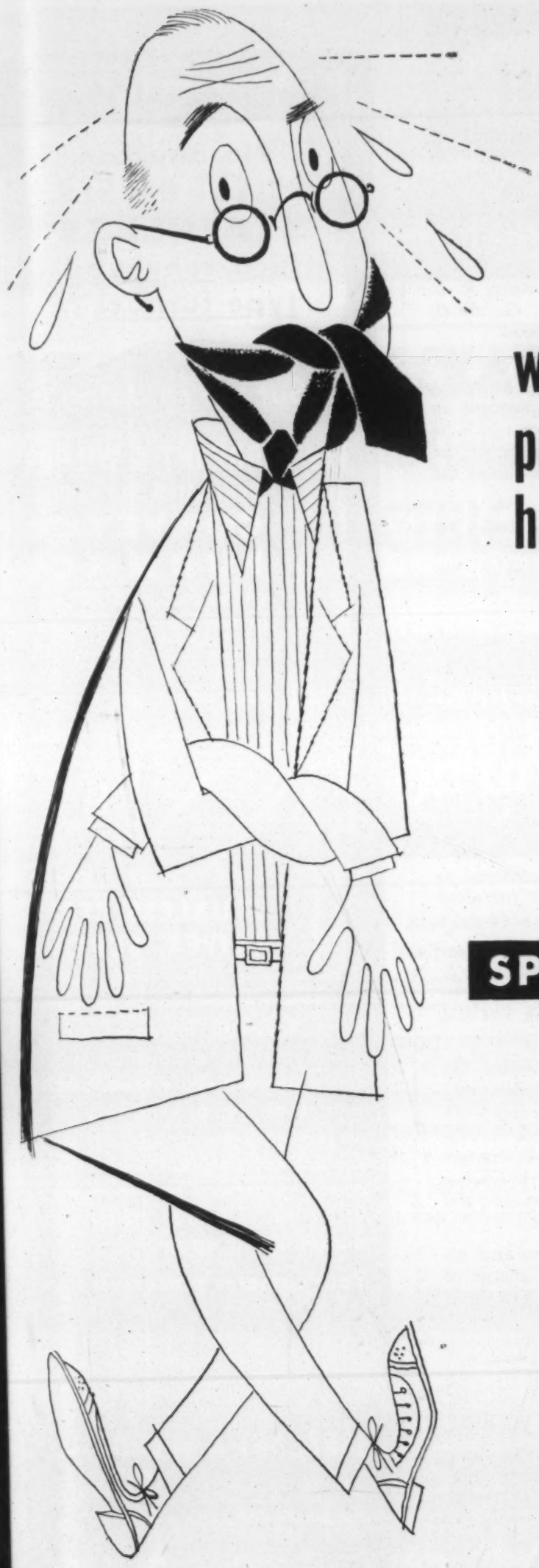

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carbon is practical and versatile because...

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Milled	High Heat Transfer (Graphite)
Broached	Low Electrical Resistance
Turned	Is Self-Lubricating (Graphite)
Planed	High Impact Resistance
Hobbed	High Thermal Shock Resistance
Ground	Not wetted by Molten Metals
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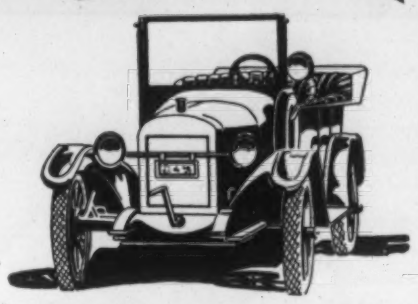

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NAME_____

TITLE_____

Attach coupon to your letterhead and mail

News Digest

Edward L. Hughes as assistants to the president.

The following appointments have been made by The Dow Chemical Co. for its new Madison, Ill., Div.: manager, *R. E. McNulty;* chief metallurgist, *G. Ansel;* and chief engineer, *Henry Burke.*

Alan R. Burman has joined The Cro-Plate Co., Inc. as a vice president, where he will organize a new department in charge of advertising and sales which he will head. Another new member of the firm is *Robert C. Allen,* who assumed the position of treasurer.

Automatic Steel Products, Inc., has elected *Curtis Franklin* chairman of the board of directors. Mr. Franklin has served as secretary, treasurer and director of the company.

Affiliated Gas Equipment, Inc., has announced the election of *J. A. Hughes* as a vice president of Affiliated, as well as his promotion from assistant general manager to general manager of the Bryant Heater Div. Simultaneously, *Robert M. Buck* was named to succeed *D. A. Campbell* as manager of Bryant Heater's Industrial Div. Mr. Buck previously served as Division engineer.

Harry W. Jobes has been appointed to the position of assistant to the president of the United States Radiator Corp.

Niagara Alkali Co. has named *William J. Weed,* manager of sales, and *Louis E. Bauer,* manager of production, vice presidents of the company. Mr. Bauer was also made a director.

New officers for Laclede-Christy Co. were elected recently. They include: president, treasurer and general manager—*D. N. Watkins;* vice presidents—*A. B. Agnow, J. L. Cummings* and *L. C. Hewitt;* controller and secretary—*E. J. Williams;* assistant secretary—*J. H. Schoemaker;* and assistant treasurer—*R. G. Jones.*

John Mikulak has been appointed assistant to the vice president in charge of manufacturing of Worthington Pump and Machinery Corp.

Johns-Manville Corp. has elected *Leslie M. Cassidy* chairman of the board and chief executive officer. *A. R. Fisher,* vice president, succeeds Mr. Cassidy as president of the corporation.

The election of *H. H. Scudder* and *A. U. Pinkney* as vice presidents of the International Standard Electric Corp. occurred recently.

George M. Hollman, Midwest regional sales manager, has been promoted to the position of manager of the Defense Production Div. for the Alloy Rods Co.

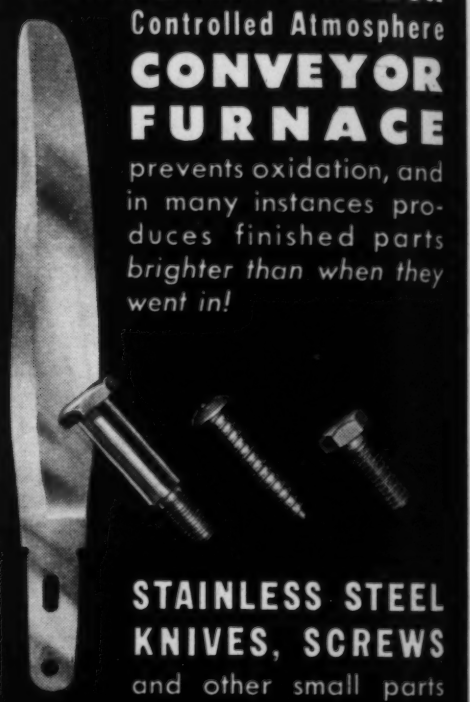
William A. Rose, 70, who retired in 1945 as president of The Bassick Co., a subsidiary of the Stewart-Warner Corp.,

It's been said:

"No one can **BRIGHT-HARDEN STAINLESS** in a conveyor type furnace"

...but we're doing it!

The SARGEANT & WILBUR Controlled Atmosphere **CONVEYOR FURNACE** prevents oxidation, and in many instances produces finished parts *brighter than when they went in!*



STAINLESS STEEL KNIVES, SCREWS and other small parts can now be brought up to maximum Rockwell hardness on a conveyor-belt, production basis, and come out **scale-free, bright** and **clean.** No pickling required, no polishing, no sand blasting — so you not only eliminate those costly operations but your processed parts retain their sharp design, sharp edges.

Your samples processed free. If you want to see some of your own work **bright**-hardened, send us samples and specifications.

SARGEANT & WILBUR, Inc.

180 WEEDEN STREET

PAWTUCKET, R. I.

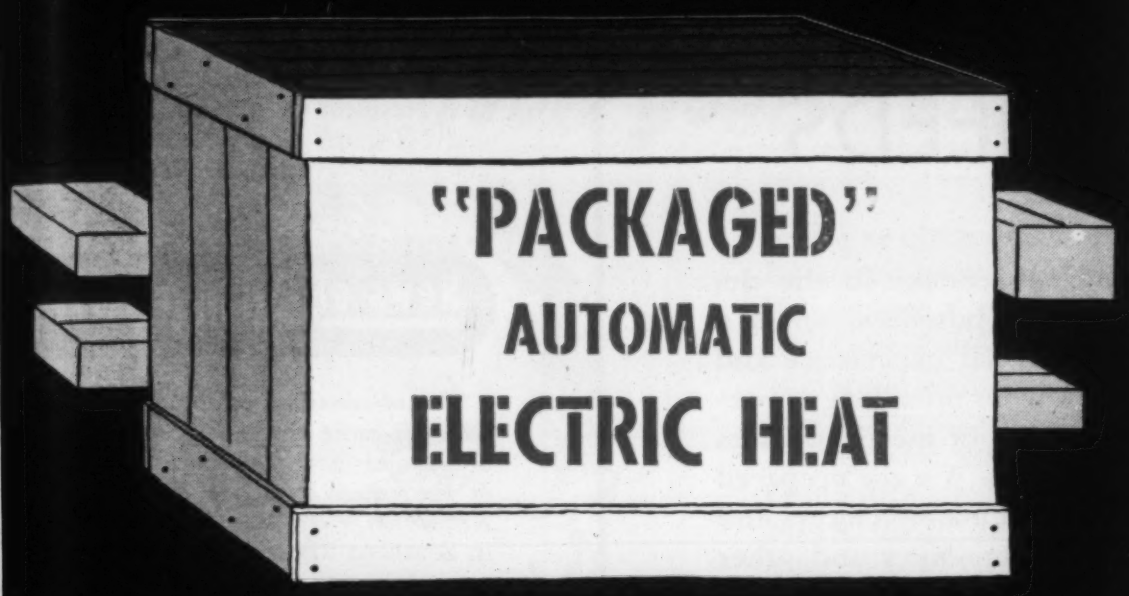
Send your illustrated folder "How to BRIGHT-HARDEN STAINLESS in the S & W Conveyor Furnace."

Name.....

Company.....

Address.....

CHROMALOX



combining Heater and Thermostat in one unit

ready to go on your Jobs!

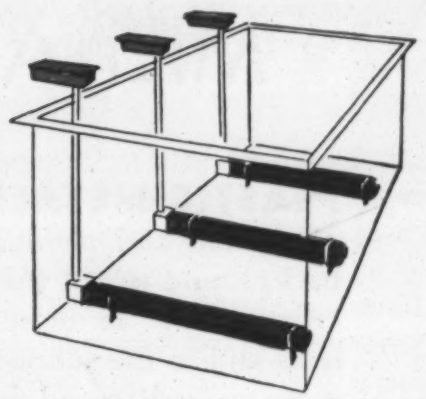
● CHROMALOX 'Packaged' Electric Heaters are ideal as permanent or portable heat sources in tanks, drums, process kettles and other containers. With CHROMALOX Heaters you can heat accurately and maintain the temperature of degreasing, cleaning, pickling and plating baths. You can melt greases, asphalt and similar viscous fluids. CHROMALOX Units may be had in the types, sizes and wattages required to efficiently do your heating jobs. They are available with sheaths of copper, stainless steel, alloy and lead for resisting the corrosive actions of the solutions you are using.

Nation-wide engineering service for on-the-job assistance and recommendations. Write, wire or phone for the name of the Chromalox Engineering Representative serving you.

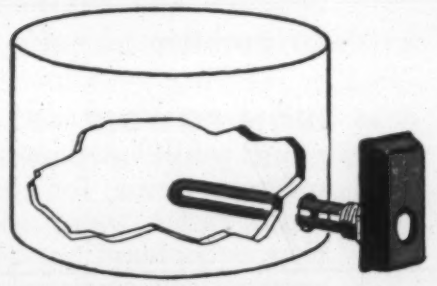
CHROMALOX

Electric Heat for Modern Industry

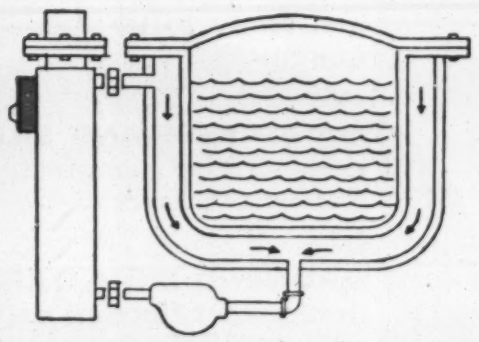
Variety and Versatility to fit your Needs Exactly



Chromalox Immersion Heaters with built-in thermostats for portable or permanent use. Drawing illustrates Immersion Units, equipped with sludge-legs, installed over the side of the tank for direct heating. Available in various metal sheaths to resist the corrosive action of the liquid compounds.



Compact, thermostatically controlled, screw-in type Chromalox Immersion Unit is easily installed in smaller tanks and other containers. Thermostat range is 100° to 180° F.



Chromalox Circulation Heaters give accurate, controlled heat up to 750° F. for heating Dowtherm, Aroclor or heat transfer oils. Other uses include water heating applications such as steam boilers and accumulators, kettles, tanks and processing equipment, preheating fuel oils, heating air, nitrogen and other gases; drying steam, plastic powders, etc.

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For complete details showing how to use Chromalox Heaters in your applications.

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IRON POWDER—For shell rotating bands; for parts for guns, tanks, airplanes, jeeps, trucks, missiles and other military items; for electronic cores and magnets used in radio, radar, sonar and other communication and detection equipment; and for a wide variety of additional applications essential to National Welfare and Defense.

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POWDER PRODUCTION FACILITIES—Plastic Metals has large scale electrolytic, reduction, pulverizing and screening facilities suitable for the processing of many types of powders in addition to those listed above and is ready to cooperate in the solution of problems involving such products.

For more detailed information, write to

PLASTIC METALS
DIVISION OF THE NATIONAL RADIATOR COMPANY
JOHNSTOWN, PENNSYLVANIA

News Digest

died at his home in Easton, Conn., after a prolonged illness.

Herman T. Kohlhass, retired assistant vice president of International Telephone and Telegraph Corp., died suddenly in an automobile accident near Jacksonville, Fla.

News of Companies

Vanadium Corp. of America, New York 17, will more than double its production of metallurgical chromium ore as a result of the recent purchase by its subsidiary, *Rhodesian Vanadium Corp.,* of properties in Southern Rhodesia, South Africa.

A new office building has just been completed at 9000 Market St. Road, Houston, by *Federated Metals Div., American Smelting and Refining Co.,* New York 5.

R. S. Aries & Associates, New York 17, have acquired the business of *William Y. Agnew,* consulting chemical engineer, also of New York City. The general engineering and drafting offices of the newly acquired company will remain at 500 Fifth Ave., while the executive offices will be transferred to the parent company at 400 Madison Ave.

A $2,800,000 plant expansion program has been launched by *Carboloy Co., Inc.,* Detroit 32. Included in the plans is enlarging of the present Carboloy plants in Detroit, and construction of a new plant in Edmore, Mich.

International Derrick & Equipment Co., Dallas 1, has sold its chain of 15 supply stores to the *H. K. Porter Co.,* Pittsburgh. Consolidation of the *Ideco Supply Div.* with the *Jarecki Supply Co.,* also owned by Porter, will result in a new oilfield distribution organization to be known as *Jarecki International Supply Div.* No change in the personnel or operation of the Division is contemplated.

A new one-story building, now nearing completion, will add 50,000 sq ft to the working area in the headquarters of *The Foxboro Co.,* Foxboro, Mass. It was also announced that Foxboro has opened a new branch office at 618 W. Church Ave., Knoxville, 16, Tenn.

The Colorado Fuel and Iron Corp. has acquired the *Worth Steel Co.,* Claymont, Del. The plant will now be operated as a wholly-owned subsidiary of C. F. & I., to be known as the *Claymont Steel Corp.* Officers of the new corporation include the following: chairman of the board—Charles Allen, Jr.; president—C. W. Myers; executive vice president—A. F. Franz; vice president and secretary—Franklin Berwin; vice president of sales—F. S. Jones; vice president of finance—A. C. Bekaert; treasurer—H. C. Crout;

(Continued on page 174)

Drop Forgings?

Now you're talking our language!

We're old hands at the business of making drop forgings; been doing it a long, long time. And during that time we've developed a complete, integrated service that in many ways simplifies things for the customer.

Here at Bethlehem you'll find both die-making and steel-making facilities; a battery of steam and board hammers, mechanical presses, and upsetters; and a full complement of modern heat-treating equipment. But that isn't all. Bethlehem offers, in addition, the services of picked metallurgists, whose job is to check on quality right down the line.

Designs? We can handle an endless variety. Weights? Approximately 1½ to 250 lb.

Over the years, Bethlehem has turned out many millions of closed-die forgings for the automotive, petroleum, aviation, electrical, mining, and other industries. This is a broad type of experience that is helpful to the user of drop forgings.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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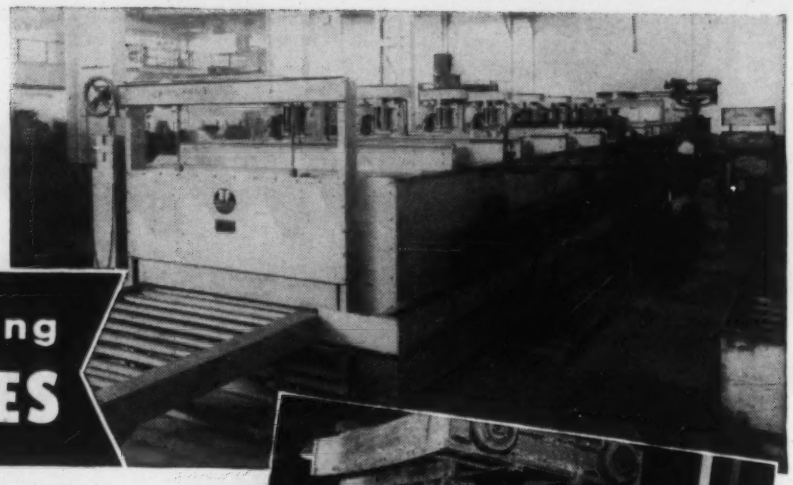

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For Ferrous and Non-Ferrous
Defense Products

Let EF engineers—with their successful record during the World Wars I and II—help you convert to defense production. Our complete facilities, plus the "know-how" gained on hundreds of shell, aircraft, tank, ammunition component and other defense projects can save you time and expense. Better write us about your change-over problems today.

Gas-Fired, Oil-Fired and Electric Furnaces
for any Process, Product or Production
THE ELECTRIC FURNACE CO.
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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field—less than 1%—with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

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AJAX ELECTRIC COMPANY, INC., *The Ajax-Holtzer Electric Salt Bath Furnace*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

News Digest

comptroller and assistant secretary—Earl D. Page; and assistant treasurer and assistant secretary—E. H. Worth, Jr.

Plans for a major expansion of its Repauno plant at Gibbstown, N. J., and the construction of a new commercial explosives plant near Martinsburg, W. Va., have been announced by *E. I. du Pont de Nemours & Co. (Inc.),* Wilmington 98, Del. The Repauno plant is scheduled to be in operation by the end of 1952.

Binks Manufacturing Co. has established a new office at 22-01 41st Ave., Long Island City 1, N. Y.

A modern aluminum foil plant has just been completed in Jackson, Tenn., by *Aluminum Foils, Inc.,* New York City. The plant was designed by engineers of the *Swiss Aluminum Co., Ltd.,* Switzerland, parent company of Aluminum Foils, and the machinery built to their specifications in American factories.

Bronze Bearings, Inc. has recently been organized to take over the manufacture and sale of bronze bearings, bushings, graphited oil-less bearings, and nonferrous castings formerly produced by *S & B Bearing Manufacturing Co.,* Cranford, N. J. Sidney Hausman is president of the new concern and Samuel P. Oppenheimer is secretary.

Construction of a new glass plant in Danville, Ky., has been started by *Corning Glass Works,* Corning, N. Y.

Sharon Steel Co., Sharon, Pa., has officially named the company's operating facilities at Farrell, Pa., the "Roemer Works", in honor of Henry A. Roemer, chief executive officer and chairman of the board of directors of the Company.

Construction of a new parts plant now being erected in Des Plaines, Ill., is the first of a series of buildings planned for this location by *Hannifin Corp.,* Chicago.

Keystone Carbon Co., St. Mary's, Pa., has recently completed the addition of 20,000 sq ft of floor space for the manufacture of powder metal parts and negative temperature coefficient resistors, as well as for office, storage and engineering facilities.

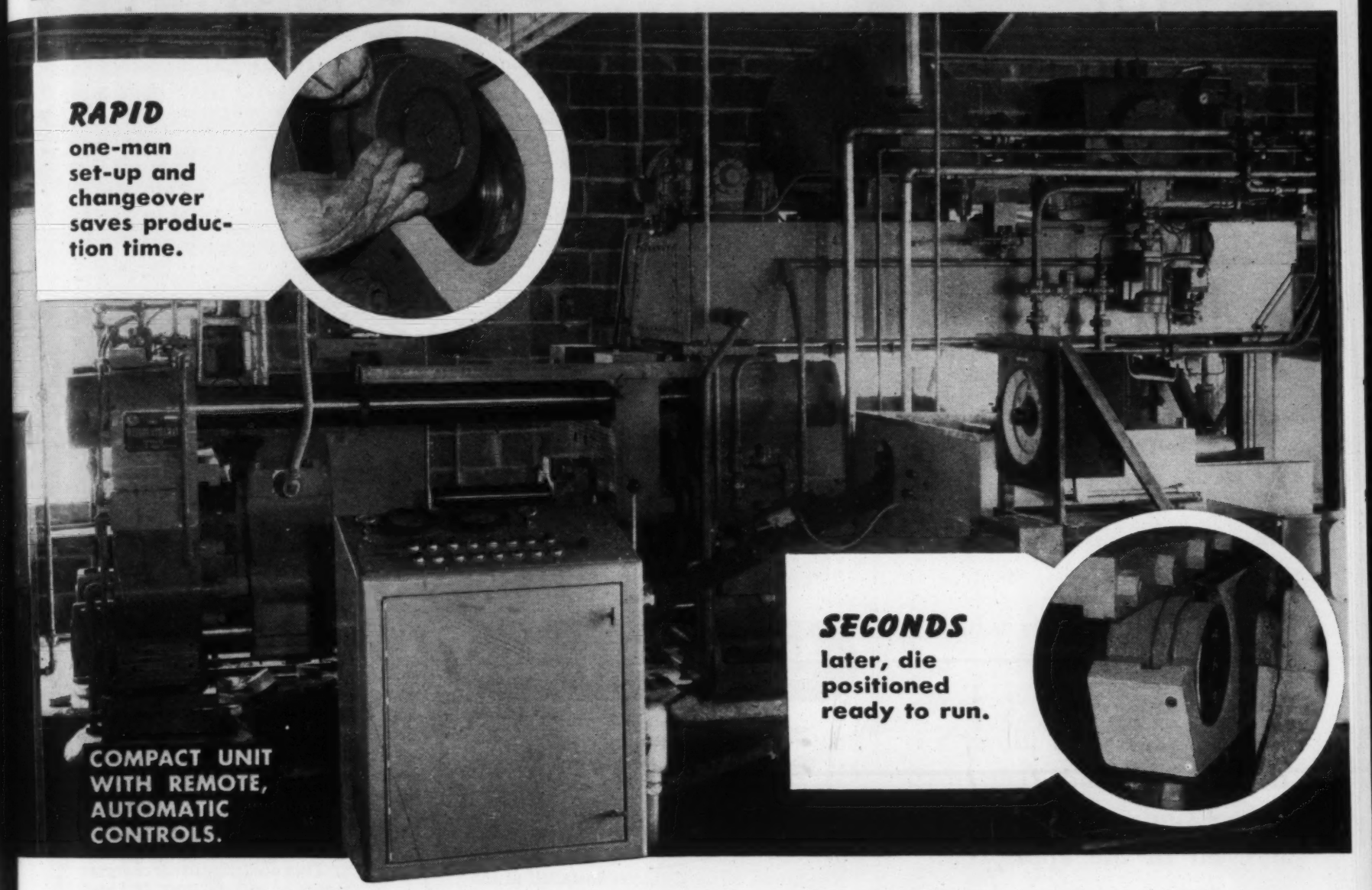
A $3,000,000 plant for the manufacture of silica refractories is to be constructed at Morrisville, Pa., by *General Refractories Co.,* Philadelphia. The Company is also enlarging its Baltimore Works, and plans to build another new plant in Los Angeles.

Reynolds Metals Co., Louisville, Ky., has taken over the management of the United States Air Force's Manufacturing Methods Pilot Plant at Adrian, Mich. The plant is available to any industry or government agency wishing to do development work on processes of either military or commercial interest.

Further expansion of present plant facilities with the opening of a new

WANT FAST . . . PROFITABLE

EXTRUDED LIGHT METALS and NON-FERROUS SHAPES?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one-man set-up and changeover saves production time.
COMPACT UNIT WITH REMOTE, AUTOMATIC CONTROLS.
SECONDS
later, die positioned ready to run.

Check with Extrusion Press "Headquarters"—WATSON-STILLMAN—for the answer to your problem.

W-S Extrusion Presses range in capacities from 750 to 5,000 Tons. Each individual machine is a completely "packaged" extrusion plant, possessing outstanding operating advantages similar to the 750 ton press illustrated.

These presses feature fast cycles with production records made possible by push button automatic cycle controls. The Die Slide design permits fast die-change—saving labor costs.

With W-S Extrusion Presses it is no longer necessary to carry expensive slow moving inventory, especially in these days of materials shortages. You can produce the extrusions you want—when you want them, at greatly reduced cost.

Investigate how your production can be improved . . . increased . . . and greater profits made. Contact the nearest W-S Representative.

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Indianapolis 20, Ind.	W. K. Millholland Machinery Co.
Los Angeles 11, Cal.	H. M. Royal, Inc.
Pittsburgh 19, Pa.	Stanley Berg & Co.
Rochester 12, N. Y.	Watson-Stillman Co.
San Francisco 7, Cal.	Schellenbach Mach. Tool Co.
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You are the man for whom we compiled "3 Keys to Satisfaction," our 72 page book full of vital information, graphs, and diagrams of real significance to all interested in the application of design to materials. Every single page carries valuable data on scientific design in relation to metallurgical properties—all from the designer's viewpoint.

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Position.....
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MOLY

MM-6 F27

News Digest

foundry division has been announced by *Rosán, Inc.*, South Gate, Calif.

Paulsen-Webber Cordage Corp., New York 7, has opened an office in New Orleans, with Harry Brownlee serving as branch manager.

Construction of a new petroleum cracking catalyst plant at Michigan City, Ind., is scheduled to begin in June, according to an announcement by *American Cyanamid Co.*, New York 20. C. S. Davis has been appointed plant manager of the new facility.

Completion of a new chromium chemical plant in Baltimore has been announced by *Mutual Chemical Co. of America.*

Two new fellowships in metallurgical engineering have been established at the Illinois Institute of Technology by the *International Nickel Co., Inc.*, New York 5. Each of the fellowships provides for two year's study leading to a master of science degree in metallurgical engineering, and carries an annual award of $1500 and tuition.

News of Societies

More than 2000 members of the *American Ceramic Society* recently met in Chicago for the Society's 53rd annual meeting. Sessions of the eight divisions included about 150 technical papers reporting on research and development in all branches of industry. Society officers installed at the meeting were: Howard R. Lillie, research physicist for Corning Glass Works, as president for 1951-52; William E. Cramer, president of Industrial Ceramics, Inc., as president-elect. Other installations included: Arthur A. Wells, vice president and general superintendent of Homer Laughlin China Co., as vice president; Ray W. Palford, vice president and general plant manager of Acme Brick Co., as vice president; Robert W. Dagar, sales engineer, H. C. Spinks Co., as vice president; Charles S. Pearce continued in his office of general secretary; Edwin M. Rupp, sales engineer, as treasurer. In addition to the installation ceremonies, the Society presented the Ross Coffin Purdy Award to Ralph K. Hursh of the University of Illinois for the most valuable contribution to ceramic technical literature during 1950.

Bryant Mather, Chief of the Special Investigations Branch of the Concrete Research Div., Waterways Experiment Station, Corps of Engineers, Jackson, Miss., was elected secretary of Committee C-9 on Concrete and Concrete Aggregates of the *American Society for Testing Materials.*

The *American Hot Dip Galvanizer's Assn.* elected the following officers for the

Sicon

New, Improved

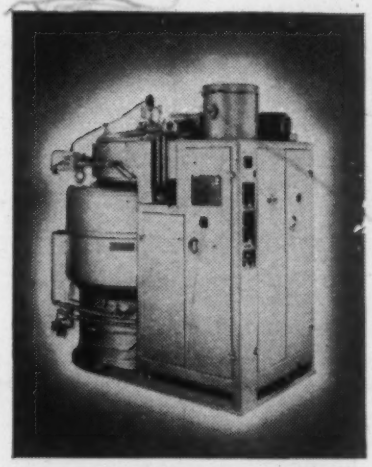
SILICONE BASE

HIGH HEAT-RESISTANT FINISH Formerly MICO

✓ **Production Line Proved**
for metal products requiring a protective coating with resistance to extreme high heat.

✓ **Withstands 1000° (F.)**
without blistering or peeling

The Vapor Clarckson Steam Generating Unit is a case in point—



☆ This unit has inside temperatures of up to 3,000° (F.) and develops full capacity in two minutes to deliver 1,000,000 b.t.u. A rugged finish is necessary to protect it not only against heat, but also against the corrosive and deteriorating influences of dirt, grime, oil, and climatic elements. SICON Aluminum is used because it answers these exacting requirements. Due to its quick drying it can be handled minutes after application. Write today for *latest tech data* describing many other SICON applications.

Sicon

Silicone-Base Finish is manufactured exclusively by

MIDLAND INDUSTRIAL FINISHES CO.
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ENAMELS · SYNTHETICS
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Another new development using

B. F. Goodrich Chemical Company *raw materials*

Hycar seal developed and made by Parker, Stearns & Co., Brooklyn, N. Y.
Photo courtesy of Republic Aviation Corp., Farmingdale, Long Island, N. Y.

safest seal

FOR A THUNDERJET

THAT'S the greenhouse of a Thunderjet, ready to slip into position. When it does it will stay sealed air-tight, even at supersonic speeds and high pressures.

You wouldn't know that the manufacturer had tried dozens of seals—all failures until Hycar was used for the job. These inflatable seals of various materials would crease and fold in the corners or pull out of the channel. Some became soft under high temperatures. Some "ballooned" into the cockpit.

All that happened before a Hycar OR-25 compound was used. The seal is a U-shaped tube with a short intake tube connected to the Thunderjet's compression pumps for fast inflation to lock the seal. The tensile strength of Hycar, its low compression set, its resistance to low and high temperatures, its oil resistance and aging make it the ideal rubber compound for the purpose.

Hycar OR-25 is just one of a wide range of highly useful rubber compounds. They've helped solve many "tough" problems, because they are so versatile. For Hycar has advantages that exactly meet many civilian *and* defense needs.

Hycar has outstanding resistance to oil, gas and many chemicals. It resists heat and cold, weather and wear, abrasion and more hard-to-meet conditions. It may be just what you need to improve or develop a product. Right now demand for Hycar exceeds supply. But we can supply experimental quantities for development work. For helpful information and technical service, please write Dept. HM-3, B. F. Goodrich Chemical Company, Rose Bldg., Cleveland 15, Ohio. In Canada: Kitchener, Ontario. Cable address: Goodchemco.

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Reg. U.S. Pat. Off.
American Rubber

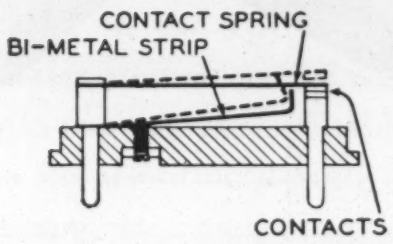
GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors

CHACE BIMETAL
Keeps Them Home on the Range!

Stevens Type "C" Thermostat (shown full size) Manufactured by Stevens Mfg. Co. Mansfield, Ohio (Patent applied for)

TELEVISION plays a big part in keeping the "small fry" at home these days, and this Stevens Type C thermostat helps keep their favorite programs on the video screen. Actuated by Chace Thermostatic Bimetal, the thermostat is used in communications equipment, electronic devices and other apparatus requiring a high degree of temperature stability.

In its television and radio application this thermostat maintains a constant ambient temperature around the quartz crystals which control transmitter frequencies; this prevents variation in these frequencies. Since it is essential that the thermostat respond only to the temperature of the device it controls, an *electrically independent* strip of Chace Thermostatic Bimetal forms the actuating element. Current flows through the stainless steel or alloy spring, but does not pass through the thermostatic bimetal. As the bimetal element responds to a predetermined ambient temperature it overcomes the spring pressure and opens the contacts. This assures a sharp, clean break and eliminates artificial cycling or life-shortening "jitters."



The simplicity, efficiency and compactness possible when using Chace Thermostatic Bimetal enables Stevens to furnish this thermostat in a wide variety of production models, each using the same actuating element. Perhaps *your* product, too, can offer extra advantages when designed around an actuating element of this versatile material. Let The Chace Application Engineer, with his background and experience in the control of temperature-responsive devices by Chace Thermostatic Bimetal, help you.

IT BENDS WITH THE HEAT

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Thermostatic Bimetal
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News Digest

coming year: president—C. L. Moorman, Equipment Steel Products Co.; vice presidents—D. B. Noland, Noland Tank & Galvanizing Co.; and Bonnie Trent, Armco Steel Corp.; secretary-treasurer—Stuart J. Swenson; and assistant secretary—S. J. Swenson, Jr.

J. L. Mauthe, president of The Youngstown Sheet and Tube Co., was selected as the 1951 recipient of the David Ford McFarland Award for Achievement in Metallurgy. The Award is presented annually by the Penn State Chapter of the *American Society for Metals.*

Election of officers has been announced by the *National Association of Aluminum Distributors.* They include: president—Harry L. Edgcomb, Jr., Edgcomb Steel Corp.; vice presidents—T. S. White, Nottingham Steel Co.; and W. W. Doxey, T. E. Conklin Brass & Copper Co.; and treasurer—Ralph Shaw, Jr., A. R. Purdy Co.

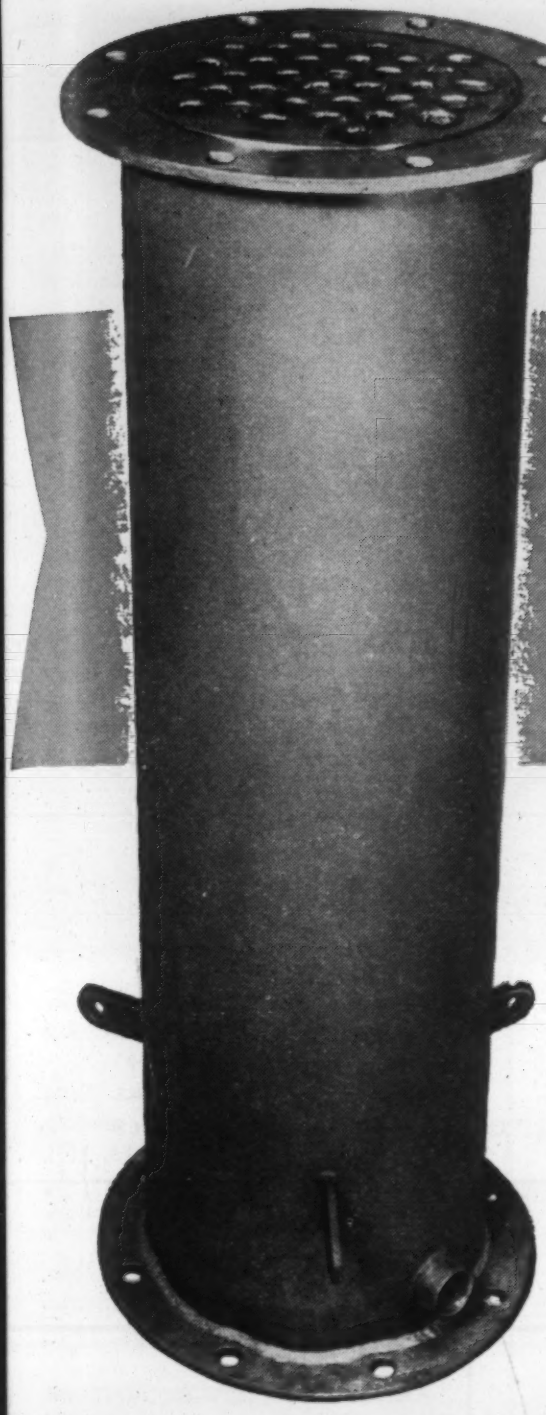
The *National Research Council* has appointed William E. Makin director of the metallurgical projects division of a new metallurgical advisory board. Mr. Makin is director of research at the Armour Research Foundation of the Illinois Institute of Technology.

National medal awards for outstanding leadership in the steel casting industry were announced by the *Steel Founders' Society of America.* The Lorenz Memorial Gold Medal was presented to Thomas H. Shartle, Texas Electric Steel Casting Co. The Technical and Operating Medal for 1950 was given to Paul H. Stuff, Ross-Meehan Foundries. And G. A. Lilliequist, American Steel Foundries, received the Steel Foundry Facts Award. It was announced at the same time that Mr. Shartle was re-elected president of the Society, while G. Rhodes Casey, Treadwell Engineering Co., was elected vice president. H. A. Forsberg, Continental Foundry & Machine Co., was named a director and executive committee member.

Newly-elected officers for the *American Society of Body Engineers* include the following: president—Harry G. Garman, Fisher Body; vice president—Harold V. Atnys, Chrysler Corp.; secretary—Gordon J. Lawton, Briggs Manufacturing Co.; and treasurer—Edward L. Pangborn, Chrysler Corp.

The Pittsburgh Section of the *American Ceramic Society* presented the Albert Victor Bleininger Award to Dr. John C. Hostetter, retired, in recognition of his "distinguished achievement in the field of ceramics."

J. J. Nolan, Jr., Central Foundry Co., was re-elected president of the *Cast Iron Soil Pipe Institute* during its annual meeting. Deems W. Hallman, Hajoca Corp., was re-elected treasurer, and J. W. Struve, Rich Manufacturing Co., was named vice president.



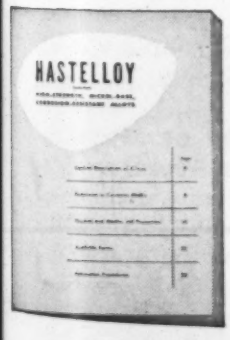
handles *Boiling HCl* for 2½ years!

This HASTELLOY Alloy Condenser is still on the job in 1-10% Acid Solution

This condenser, made of HASTELLOY alloy B, shows no signs of corrosion after two and one-half years in a vacuum still for the distillation of hydrochloric acid. Since it was installed, the unit has been in operation two to three days a week, eight hours a day, handling a dilute solution of the corrosive acid at temperatures up to the boiling point.

HASTELLOY alloy B is one of the few commercially available materials that can handle boiling hydrochloric acid—one of the most severely corrosive agents known to the chemical industry. Alloy B is available in all standard wrought forms and can be fabricated by most common methods. Two additional HASTELLOY alloys, designated as C and D, are also available for handling other highly corrosive chemicals, such as sulphuric acid and certain strong oxidizing agents, like ferric chloride and wet chlorine.

The 28 in. tubes in this condenser for the distillation of hydrochloric acid are made from ½-in. diameter, 16-gage welded tubing of HASTELLOY alloy B. The end disks, which are ⅜ in. thick by 7 in. in diameter, are also of the nickel-base alloy.



For complete information, write for the 40-page booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys." It contains data on the properties, available forms, and fabricating techniques for all three grades of HASTELLOY alloy.

HAYNES TRADE-MARK *alloys*

"Hastelloy" and "Haynes" are trade-marks of Union Carbide and Carbon Corporation.

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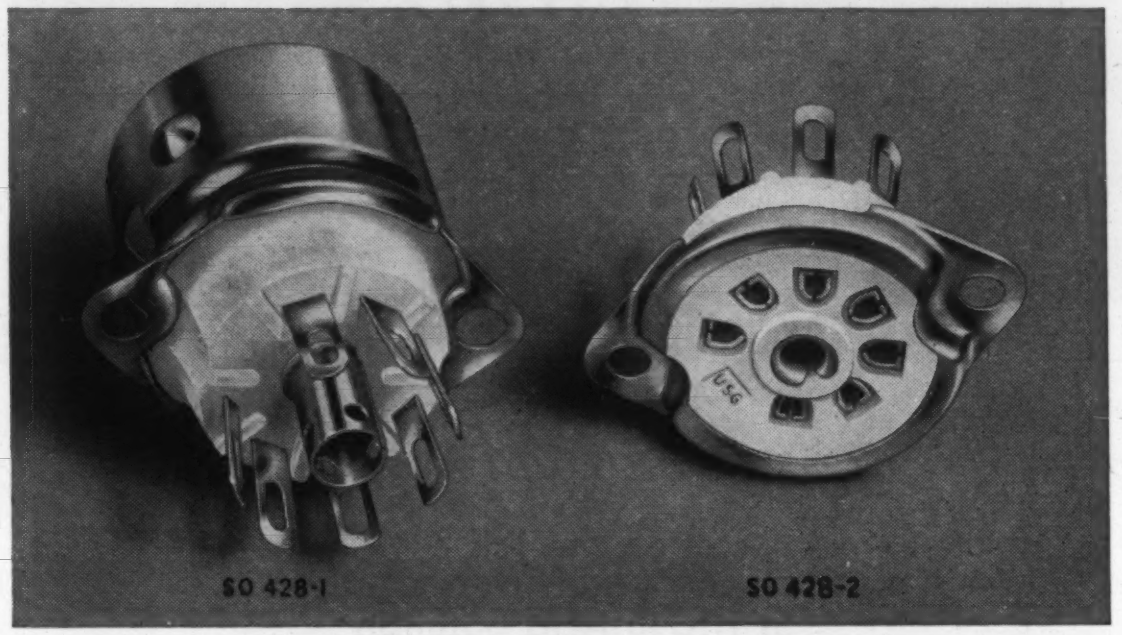

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TUBE SOCKETS

Tube sockets are another excellent example of the many unique applications United States Gasket engineers are making with Teflon—the plastic that is:

- **Chemically inert**
- **Mechanically tough**
- **Heat-resistant**
- **Extremely anti-hesive**

Throughout industry, materials men are finding Teflon's combination of properties the answer to tough problems. Teflon expansion joints for corrosion-proof piping systems, Teflon diaphragms, pump cups, stop-cocks, nozzles, Teflon insulators for high-frequency electrical equipment are just a few successful applications of Teflon fabricated by USG.

Teflon is also supplied in sheets, cylinders, rods, tubing and bars.

For complete information write for USG Catalog No. 300.

TEFLON PRODUCTS DIVISION

UNITED STATES GASKET CO.
656 North 10th Street, Camden, New Jersey

Meetings and Expositions

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City, N. J. June 18-22, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, applied mechanics West Coast conference. Stanford, Calif. June 22-23, 1951.

MALLEABLE FOUNDERS' SOCIETY, annual meeting. Hot Springs, Va. June 22-23, 1951.

ALLOY CASTING INSTITUTE, annual meeting. Hot Springs, Va. June 24-26, 1951.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Toronto, June 25-29, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil & Gas Power Div. conference. Dallas. June 25-29, 1951.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual summer meeting. Los Angeles. June 27-28, 1951.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, semi-annual meeting. Portland, Ore. July 2-4, 1951.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. Buffalo. July 30-Aug. 2, 1951.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Seattle, Wash. Aug. 13-15, 1951.

AMERICAN CHEMICAL SOCIETY, diamond jubilee meeting. New York. Sept. 3-7, 1951.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor and production forum. Milwaukee. Sept. 10-13, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments & Regulators Div. and INSTRUMENT SOCIETY OF AMERICA, exhibit and joint conference. Houston. Sept. 10-14, 1951.

INTERNATIONAL FOUNDRY CONGRESS. Brussels, Belgium. Sept. 10-14, 1951.

STEEL FOUNDERS' SOCIETY, fall meeting. Hot Springs, Va. Sept. 24-25, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Petroleum Mechanical Engineering conference. Tulsa, Okla. Sept. 24-26, 1951.

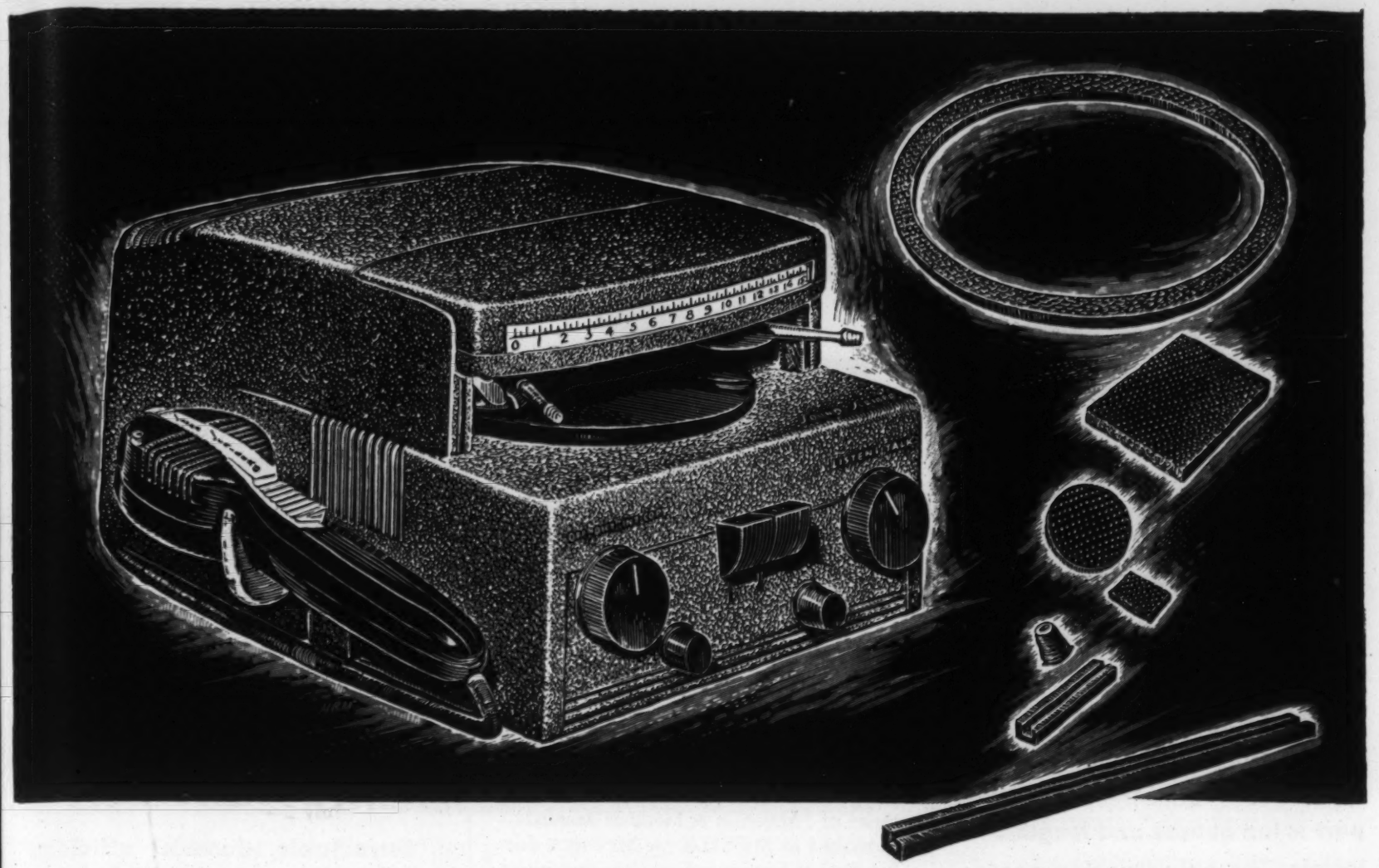
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting, Minneapolis. Sept. 25-28, 1951.

NATIONAL METAL TRADES ASSOCIATION, annual convention. Chicago. Sept. 26-28, 1951.

INDUSTRIAL PACKAGING & MATERIALS HANDLING EXPOSITION. Cleveland. Oct. 1-4, 1951.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual convention. Chicago. Oct. 1-4, 1951.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Petroleum Branch fall meeting. Oklahoma City, Okla. Oct. 3-5, 1951.

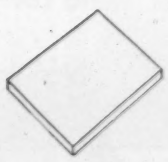


SoundScriber screens noise and prevents damage to delicate parts with

SPONGEX®

CELLULAR RUBBER

TURNTABLE CUSHION — prevents transmission of motor vibrations to recording disc. Cushion permits clear, noise-free recording. ***A custom-molded Spongex part.***



AMPLIFIER INSULATOR — provides wall of insulation between plug-in amplifier and main electrical chassis. ***Part is die-cut Spongex sheet stock.***

HAND MICROPHONE SPACERS — microphone element "floats" between rubber spacer cushions. These spacers protect the element from damage, and insulate it against transmitting the sound that would otherwise result from dropping or banging the microphone. ***Spacers are die-cut Spongex sheet stock.***

MOTOR SHOCK ABSORBERS — absorb shock in motor suspension and dissipate motor vibration. ***Custom-molded Spongex***

AMPLIFIER GASKET — protects the amplifier from damage should machine be banged about, as often happens on business trips. ***Custom-molded Spongex.***

This new booklet on the properties of, test data on, and specifications for cellular rubber has just been released. It's concise, and a valuable reference source. Write for a free copy today.

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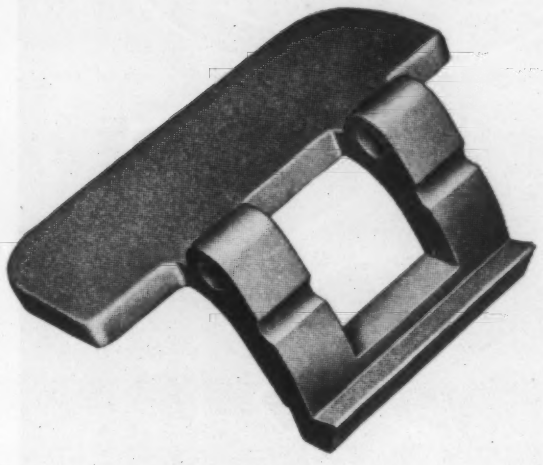

Illustrated above is a bronze part made by the Precision Investment Casting process. Weight of the part is ten ounces and length 3½ inches. The only finishing operation is to ream the holes. Our customer is then able to assemble a satin smooth, finished part into his machine. Surface finishing costs of sand castings, and machining of critical dimensions to tolerances are eliminated. This process might also save you money on some of your parts.

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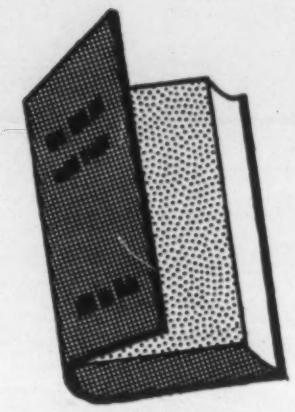

BOOK REVIEWS

Engineering Materials

ENGINEERING MATERIALS MANUAL. *Edited by T. C. DuMond. Published by Reinhold Publishing Corp., New York 18, N. Y., 1951. Cloth 8¾ by 11¾ in., 386 pages. Price $4.50.*

Here is the long awaited publication of the collected manuals on engineering materials that have appeared in the famous series of "Materials & Methods Manuals," published in MATERIALS & METHODS during the last few years. Complete descriptive information and reference data are given on every engineering material of interest to industry.

The volume comprises 28 sections, each presenting the complete story on a single material or group of materials. There are sections on irons, steels, stainless steels, aluminum, magnesium, copper alloys, plastics, rubber, ceramics, several types of finishes and coatings, and many other subjects of general interest. Important engineering information essential to designers and others concerned with materials selection and processing is included.

The real importance of this book transcends the voluminous supply of timely, authoritative and complete reference information on the specific design and manufacturing problems and procedures covered in each section. Even more important than the detailed data presented is the manner in which it is presented. The curse of technical books and articles in the past has been the tendency of editors and authors to emphasize the amount of technical detail without due consideration to the clarity and completeness of the exposition. The technical minutia are usually well known to the expert, but without an adequate introduction to the subject and a well written description of current practice, the new arrivals in the field are sure to founder. The Materials & Methods Manuals included in this book have been carefully written and edited with this in mind. The details of design, fabrication and applications are there for the expert, but, in addition, the fundamentals of each subject are clearly laid out for people without previous experience in the field, to allow a fair evaluation of each material for new applications and to guide the young technician in the materials engineering field.

(More reviews on page 184)

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You can help speed up production by giving him air when and where needed.

Retractable, durable, efficient, light-weight, non-collapsible Spiratube follows him around corners, down shafts, above and below decks, into out-of-the-way places . . . BLOWING OR EXHAUSTING. Designed for maximum air passage. Sections couple tight, fast, for permanent or portable service. Spiratube fits into present systems. Standard sizes for all requirements immediately available from well-stocked distributors — Coast-to-Coast. Used by leading public utilities, shops, mines, shipyards, and industry everywhere.

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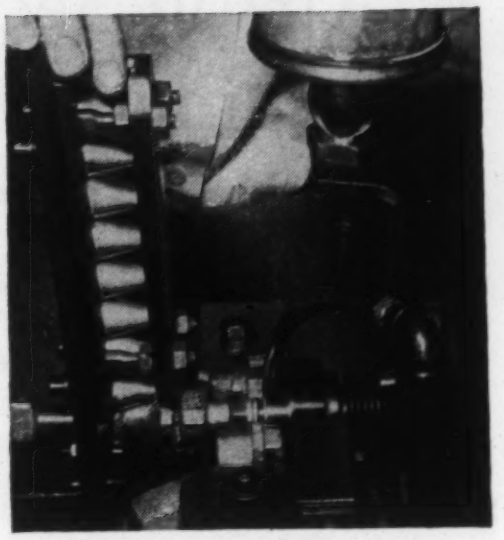
For Defense or Civilian use — get the mo$t for your Zinc Die Ca$ting Dollar!

Whether for defense or essential civilian products, design ZINC Die Castings *specifically* for this metal and method of production—to achieve maximum economy. The two ZINC Die Cast fuse noses for 20 mm. ammunition pictured above were designed to give Uncle Sam the most for his dollar. The same economic considerations apply to essential civilian castings.



MINIMIZE MACHINING

ZINC Die Castings are often produced so close to finished dimensions that little or no machining is required. In designing the fuse noses, however, it was less costly to cut the external threads than to cast them. Since the ZINC alloy is free-cutting, this operation is performed at high speed in a lathe fitted with an automatic feeding mechanism.

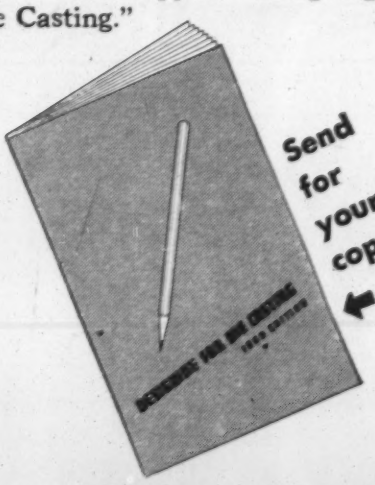
For a working knowledge of the full economic possibilities of ZINC Die Castings for defense or essential civilian products, ask us—or your die caster—for a copy of "Designing For Die Casting."

UTILIZE MULTIPLE PRODUCTION

Using a die designed to produce 12 fuse noses at a time, on a "gate" which is cast at the rate of 225 to 250 per hour, over 2700 noses are produced every 60 minutes in a plunger-type die casting machine. Of the most used die casting metals, only ZINC alloys can be used in these high speed machines.

DON'T WASTE METAL

All excess metal is sheared off when the 12 castings are removed from the gate simultaneously in a punch press. Thus all of the flash metal, as well as the gate, is salvaged for remelting and reuse. This not only minimizes metal cost but conserves zinc which is so essential to the National Defense program.



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FOR DIE CASTING ALLOYS

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The Research was done, the Alloys were developed, and most Die Castings are based on

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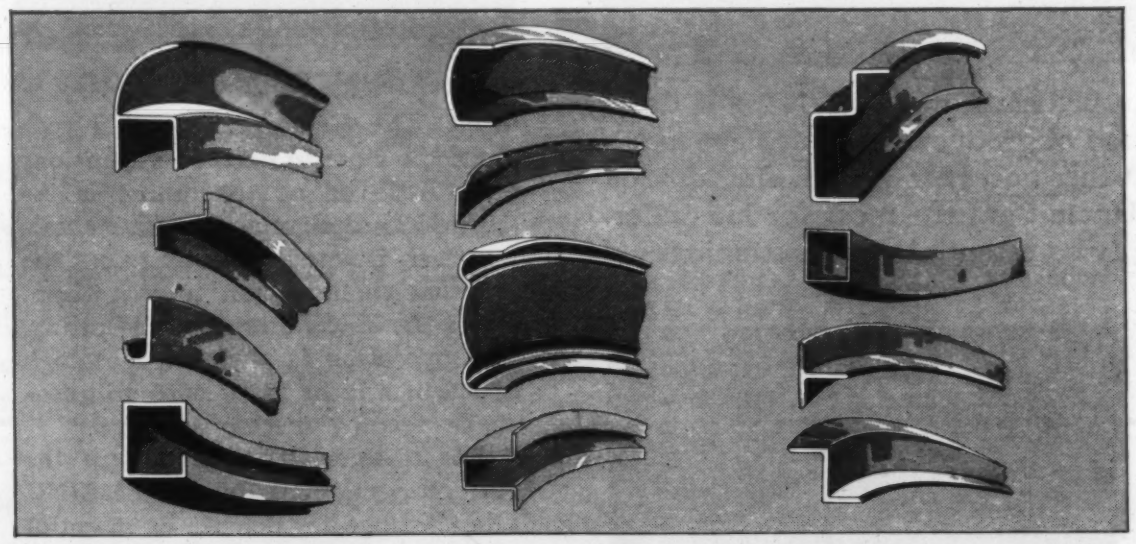
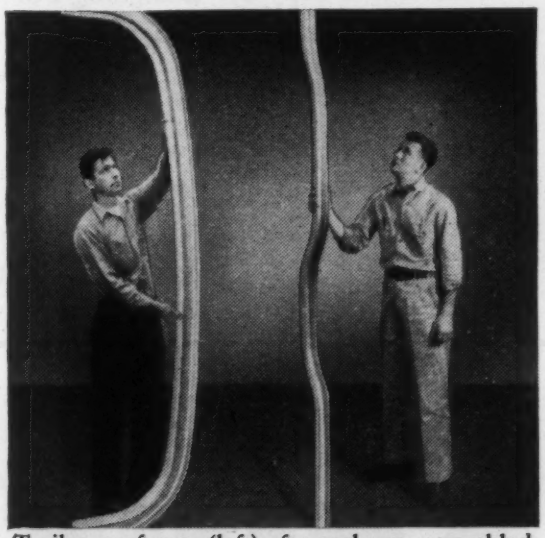
√ Air Frame Sections
√ Airplane Skin Sections
√ Airfoil Sections
√ Engine Containers
√ Helicopter Frames

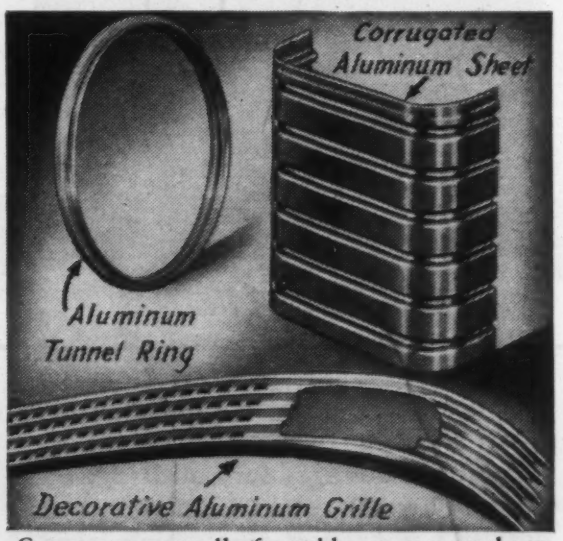
Our Custom Forming Division serves metal working industries by bending and fabricating—from many cross sections, whether extrusion, rolled, bar, strip or sheet—in any metal, whether aluminum, carbon, alloy steel, stainless or bronze—to most any curve, whether shallow or sharp, constant or compound. Send blueprints and production requirements for prompt quotation.



A few of the cross sections curved and bent by BATH Metal Form Division.



Trailer roof cap (left), formerly an assembled section, is formed in one piece by BATH. Coach frame (right) includes reverse bends.



Curves not normally formable, or too costly to form on conventional equipment, are no problem for the BATH method.

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Book Reviews

(continued)

Sheet-Metal Fabricating

PRINCIPLES AND METHODS OF SHEET-METAL FABRICATING. *By George Sachs. Published by Reinhold Publishing Corp., New York 18, N. Y. Cloth, 6¼ by 9¼ in., 526 pages. Price $10.00.*

This book, written by one of the leading technical authorities on cold working of sheet metals, is an outstanding reference work in the field. It describes systematically and in great detail the principles of numerous sheet metal forming methods, emphasizing their similarities and differences. It covers the theory of deformation of sheet metal and tubing; the metallurgical effects produced in stamping, drawing, extruding, bending, etc.; the practical operations involved; the design of parts and dies; and the production equipment used. All this information is of special importance in the defense production program now under way.

The materials engineer can learn everything he wants to know about the interrelation between the variables of sheet metal forming, the metal properties, part design and fabricating methods. The principles of forming operations can be firmly grasped so that the experience gained in the forming of certain parts can be applied to the design of tools and to the development of blank sizes and contours required for the production of other, different-appearing parts. This knowledge should help to reduce the expensive waste in time and material which is frequently associated with metal working, particularly sheet-metal fabricating.

The theoretical concepts are applied to practical problems in a way that emphasizes the how-to-do-it nature of the book that is of real value to practical design engineers and metallurgists. Numerous examples of commercial work are given and analyzed so that it can be clearly understood just how specific jobs are done.

Other New Books

SYMPOSIUM OF ULTRASONIC TESTING. *Published by the American Society for Testing Materials, Philadelphia 3, Pa., 1951. Paper, 6 by 9 in., 133 pages. Price $2.00.* A summary of the history, theoretical aspects, basic principles of practical testing, and practical applications, for the ultrasonic testing of materials as presented at the 52nd annual meeting of the Society, sponsored by the ASTM Committee E-7 on Non-Destructive Testing. This book is designated Special Technical Publication No. 101.

WELDING, JOINING AND CUTTING OF GRAY IRON. *By C. O. Burgess. Published by Gray Iron Founders' Society, Inc., Cleveland 14, Ohio, 1951. Paper, 6 by 9 in., 42 pages. Price $1.75, non-members; $1.25, members.* This booklet is a preprint of the material that will constitute Chapter VII of the forthcoming "Gray Iron Handbook", which is being prepared by the Technical Dept. of the Society.

MANUFACTURERS LITERATURE

Materials

Irons • Steels

Cold-Formed Steel Shapes. Bethlehem Steel Co. Booklet illustrates various types of cold-formed steel shapes made from strip, sheet or plate giving their features and possible applications. (1)

Steel Design. Climax Molybdenum Co., 72 pp. Booklet tells how to combine good design, high quality steel and proper treatment for best results with steel components. (2)

Stainless Steel. Crucible Steel Co. of America, 31 pp, ill. Shows, through applications in textile industry, savings available to users of stainless steel. (3)

Low Alloy Steel. Inland Steel Co. Data on easy-to-fabricate Hi-Steel, strong, abrasion and corrosion resistant structural steel with high fatigue strengths. (4)

Machinable Steels. Jones & Laughlin Steel Corp. Properties and grades of J & L "E" Steel, said to have high machinability, give better finishes, and extend tool life. (5)

Stainless Clad Steel. Alan Wood Steel Co., No. D-97. Properties and applications of Permaclad stainless clad steel affording surface characteristics of stainless steel, formability of carbon steel. (6)

Nonferrous Metals

Specially Processed Brass. The American Brass Co., No. B-39. Working properties of Formbrite processed copper alloy sheet, strip and wire claimed to be superior to ordinary brass. (7)

Clad Metals. American Cladmetals Co. Use of clad metals stresses as solution to problem of conserving strategic alloys. (8)

Silver Brazing Alloy. American Platinum Works. Physical characteristics and uses of an A.P.W. No. 355 silver brazing alloy, closely matching stainless steel in color. (9)

Continuous Cast Bronzes. American Smelting and Refining Co. Catalog of Asarco continuous cast bronzes giving physical properties, weights and stock shapes and sizes. (10)

Low Temperature Melting Alloys. Cerro de Pasco Corp. Technical data and applications of Cerro low temperature melting alloys useful in many phases of industry. (11)

Magnesium. Dow Chemical Co., 8 pp, ill, *Magnesium Topics*, Vol. 1, No. 4. Articles on extrusion of powdered magnesium alloys and sand casting magnesium. (12)

Nickel Alloy Products. Driver-Harris Co., 4 pp, ill. *D-H Alloy Craftsman* describes various applications of Nichrome and monel wires and forms. (13)

Aluminum Alloy. Federated Metals Div., 4 pp, ill. Features, foundry characteristics and mechanical and physical properties of Tenzaloy, high strength aluminum casting alloy. (14)

Corrosion Resistance Computer. The H. M. Harper Co. Matches corrosive agents against those metals best able to resist them. (15)

Nickel-Base Alloys. Haynes Stellite Div., Union Carbide and Carbon Corp., 40 pp. Properties, specifications and uses of Hastelloy corrosion resistant grades. (16)

Metal Hydrides. Metal Hydrides, Inc., 4 pp. Describes metallurgical and chemical hydrides, their use in alloying, hydrogen production, reduction of compounds, etc. (17)

Bronze and Babbitt Metals. National Bearing Div., 2 pp. Price lists of "Tiger Bronze" cored and solid bars and babbitt metals for bearing usage. (18)

Nonmetallic Materials • Parts

Colloidal Graphite. Acheson Colloids Corp., No. 426-18F. Technical data illustrating advantages available to users of "Dag" colloidal graphite as lubrication in metalworking. (19)

Molded Soft Rubber. Acushnet Process Co., 32 pp, ill, No. 50. Describes facilities for making wide range of precision molded soft rubber parts to order. (20)

Felt Seals. American Felt Co. Data Sheet No. 11 gives detailed design factors and applications of felt seals. (21)

Extruded Plastics. The Anchor Plastics Co., 8 pp, ill, No. AP51. Shows numerous applications of extruded thermoplastics and brief characteristics to aid in selection. (22)

Rubber Parts. Automotive Rubber Co., Inc. Series of bulletins show use of rubber for insulation or corrosion prevention in industrial equipment. (23)

Vinyl Acetate Resins. Bakelite Div., 20 pp, ill, No. P-3. Describes forms, properties and applications of this firm's vinyl acetate resins, useful in adhesives. (24)

Low Pressure Molding Material. Bolta Products Sales, Inc., 4 pp, ill. Specifications, features and applications of Boltaron low-pressure molding material said to be exceptionally durable. (25)

Bonded Abrasives. The Carborundum Co., 48 pp, ill, No. 3. Properties and performance characteristics of MX bonded abrasives. Shows various abrasive products and applications. (26)

Commercial Glass. Corning Glass Works, No. B-83. "Properties of Selected Commercial Glasses" gives features of various types of glass and suggests industrial applications. (27)

Plywood. Douglas Fir Plywood Assn. Descriptions and other useful data on plywoods presented in "Basic Plywood Catalog". (28)

Silicone Compound. Dow Corning Corp., 4 pp, ill. Data on D.C. Antifoam A, silicone compound for killing foam in aqueous solutions. Typical applications included. (29)

Plastics Parts. Durez Plastics & Chemicals, Inc. Monthly *Durez Plastics News* presents latest developments in use of this firm's resins and molding compounds. (30)

Laminated Thermosetting Plastics. The Formica Co. Catalog gives full information on company's facilities for complete machining of Formica custom-made parts. (31)

Molded and Laminated Plastics. General Electric Co., Plastics Div., 16 pp, ill, No. 16/13. Shows various laminated and molded plastics, their applications and several pages of general properties. (32)

Rubber-Cushioned Parts. General Tire & Rubber Co., 12 pp, ill. Describes General Silentbloc method of mounting, coupling or isolating moving machinery on rubber. Shows standard parts and specifications. (33)

Rubber Reinforcing Resin. Goodyear Tire & Rubber Co., Chemical Div., No. 601-B. Features and applications of Pliolite S-6B resin giving greater plasticity in rubber processing at low temperatures. (34)

Plastic Molding. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding and finishing. (35)

Perforated Materials. The Harrington & King Perforating Co., No. 62. Catalog gives data on fabrication methods, how to order, types of perforation and uses of perforated materials. (36)

Thermoplastic Molding Powder. Hercules Powder Co., 15 pp, ill. Applications, specifications and ordering data on cellulose acetate molding powders. Includes detailed properties charts. (37)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 189.

MANUFACTURERS' LITERATURE

Acid Proof Ceramic Pipe. Maurice A. Knight, 12 pp, ill. Specifications and descriptions of this company's ceramic pipe and fittings said to be almost universally acid proof. (38)

Plastics Parts. Rogers Corp., 36 pp. Features of Fiberloy laminated and impact phenolics, vulcanized fibres and paperboards indicating possible applications. (39)

Injection Molding Powders. Rohm & Haas Co., 12 pp, No. PL-35. Recommends procedures and remedies for avoiding certain defects in the injection molding of Plexiglas. (40)

Cellular Rubber. Rubatex Div., Great American Industries, Inc., No. RBS-12-49. Features of Rubatex closed cell rubber for cushioning, gasketing and shock-absorbing. (41)

Synthetic Rubber. Rubber Chemical Div., E. I. du Pont de Nemours & Co., Inc., 12 pp, ill, No. 43. Uses of Neoprene in parts necessitating high chemical resistance. (42)

Sponge Rubber Products. Sponge Rubber Products Co. Shows properties, forms and wide applications of cellular rubber for cushioning, gasketing, sealing, etc. (43)

Carbon and Graphite Parts. Stackpole Carbon Co., No. 40. Shows numerous standard parts and includes helpful data on the selection of carbon-graphite products. (44)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds designed to resist temperature, abrasion, chemicals and weathering. (45)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (46)

Ceramics. Stupakoff Ceramic & Manufacturing Co., 4 pp, No. 849. Properties of Stupalith, new ceramic said to be unsurpassed in thermal shock resistance. (47)

Carbon-Graphite Parts. U. S. Graphite Co., 68 pp, ill, No. G-49. Properties, chemical resistance, limitations, assembly information, design aids and 60 applications of Graphitar. (48)

Polyester Resins. U. S. Rubber Co., Naugatuck Chemical Div., 18 pp. Properties and applications of Vibrins, thermosetting polyester resins. Includes details on pressure laminating and casting. (49)

Plastics Parts. Watertown Manufacturing Co., 44 pp, ill. Complete data on properties and applications of plastics produced by this company. (50)

Felt. Western Felt Works, 32 pp, ill. History of manufacture and uses of felt, including brief description of present-day methods and applications. (51)

Flexible Hose. The Wiremold Co., 4 pp, ill, No. 567. Description, applications and types of this firm's flexible reinforced rubber air ducts for finishing applications. (52)

Metal Parts • Forms

Aluminum Extrusions. Aluminum Co. of America. Design potentials of extrusion process and cost savings in fabrication and assembly of extrusions explained. (53)

Certified Die Castings. American Die Casting Institute, Inc. Discusses plan to protect zinc alloy die castings buyers by subjecting producers to regular testing. (54)

Bonded Metals. American Nickeloid Co., 16 pp, ill. Fabricating information and suggestions, applications and tables of properties and sizes of Nickeloid Metals. (55)

Precision Castings. Austenal Laboratories, Inc., Microcast Div., 16 pp, ill. Describes Microcast Process for manufacture of precision cast parts, including specifications and explanation. (56)

Magnesium Parts. Brooks & Perkins, Inc. Characteristics of, and design data on magnesium alloys. Shows examples of made-to-order parts produced. (57)

Steel Tubing. Bundy Tubing Co., 20 pp, ill. Properties, specifications and typical parts of Bundyweld double-walled, copper-coated steel tubing. (58)

Thermostatic Bimetal. W. M. Chace Co., 4 pp, ill, No. 1a/10. Properties of thermostatic bimetals and formulae to use in application to temperature responsive devices. (59)

Steel Castings. Continental Foundry & Machine Co., 32 pp, ill. Booklet presents 12 considerations that should be taken into acccount in buying steel castings. (60)

Forged Metal Quality. Drop Forging Assn., 6 pp, ill. Details of several hot working processes emphasizing improvements achieved in metal structure using these processes. (61)

Investment Castings. Gray-Syracuse, Inc., 4 pp, ill. Various parts of precision-cast brass, bronze, beryllium copper and steel. (62)

Perforated Metals. Hendrick Manufacturing Co., 4 pp, ill. Examples of perforated metal applications and various available perforation types. (63)

Precision Castings. Hitchener Manufacturing Co., Inc., 6 pp, ill. Folder shows typical products of this firm's investment casting process. Lists advantages and design aids. (64)

Die Castings. The Hoover Co., Die Castings Div. Describes die casting process, gives essential design data, including draft, tolerance and wall thickness and core size requirements. (65)

Permanent Magnets. Indiana Steel Products Co., 34 pp, *Permanent Magnet Manual*, No. 3. Uses, types and materials of permanent magnets. Includes design data. (66)

Helical Compression Springs. Instrument Specialties Co., Inc., 2 pp, ill. How to obtain economical assortment of 1100 beryllium copper compression springs for development work. (67)

Precision Cast Parts. The Jelrus Co., Inc. Advantages of centrifugal precision casting for custom manufacture of complex parts accurately and quickly. (68)

Sleeve Bearings. Johnson Bronze Co. Series of data sheets gives detailed design, construction and testing data on sleeve bearings. (69)

Cemented Carbide Parts. Kennametal Inc., 72 pp, ill, No. 51. Characteristics of Kennametal compositions, design suggestions for their use, and descriptions of numerous standard parts. (70)

Pressed Parts. Lenape Hydraulic Pressing and Forging Co. Catalog shows numerous parts press formed by this company illustrating the kinds of jobs this firm can perform. (71)

Tungsten Carbide Parts. Metal Carbides Corp., 68 pp, ill, No. 50-G. Descriptions, specifications and prices of standard Talide Metal dies, rolls, bushings, forms and special shapes. (72)

Powder Metal Parts. Metal Powder Products, Inc., 2 pp, ill. Lists types of parts this company manufactures to order from metal powders, their cost-saving advantages. (73)

Seamless Tubing. National Tube Co. Explains time- and cost-cutting fabricating applications of this company's Shelby seamless steel tubing. (74)

Nonferrous Die Castings. The New Jersey Zinc Co., 28 pp, ill. Applications and principal features of Zamak-3 and Zamak-5 zinc alloy die castings. (75)

Nonferrous Powder Parts. The New Jersey Zinc Co. "Applications and Properties of Nonferrous Powder Parts" includes 14 case histories indicating cost savings in manufacture of brass powder parts. (76)

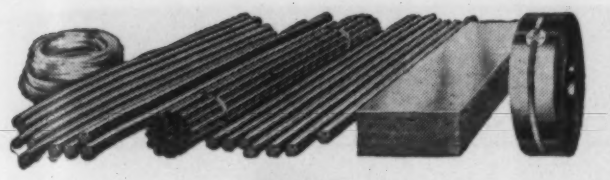
Precision Castings. Ohio Precision Castings, Inc., 12 pp, ill. Numerous examples of industrial applications of this company's brass, bronze, aluminum and beryllium copper plaster mold castings. (77)

Seamless Tubing. The Ohio Seamless Tube Co., 12 pp, ill. Shows differences in fabrication of such tubings as mechanical seamless, aircraft seamless, resistance welded and forged, listing advantages and applications. (78)

Copper Tubing. Penn Brass & Copper Co., 6 pp, ill. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (79)

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, ill. Describes Phoenixspun method for spinning spherical and extra deep-drawn contours. (80)

Metal Powder Parts. Plastic Metals Div., 4 pp, ill, No. 567. Describes applications, advantages and limitations of powder

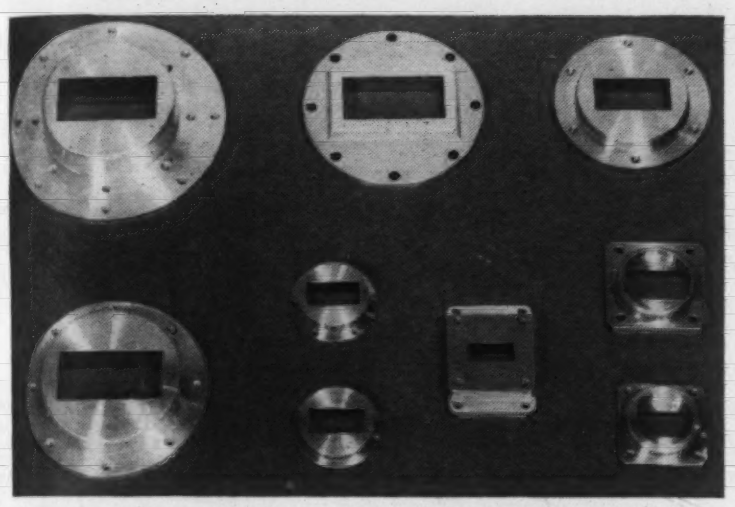


BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

"Bridgeport" BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Design of Fixtures and Correct Methods Vital in Machining



Microwave flanges machined from leaded commercial bronze. These flanges are turned, drilled, tapped and broached.

Many screw machine shops are being slowly obliged to add equipment to do secondary operations such as milling, drilling and tapping due to the stepped-up tempo of the war effort.

Since copper alloys have always been considered easy to machine, it is very easy to design holding fixtures much too light. For this same reason, it is quite simple to overlook certain methods which might help to eliminate down-time or step up production.

In milling operations, for example, in many cases fine chatter marks can be traced directly to too light holding fixtures or poor holding devices. Although it is true brass is readily cut, if the milling cutter is set up with an indicator to insure against face and side runout, not only will the cutter last longer but the finish will be better. Seldom is the cutter ground eccentrically. The trouble usually is found in a bent arbor, unaligned out-rigger or spacers with unparallel faces.

Watch Clearance Angles

After several sharpenings, it is necessary on circular milling cutters to regrind clearance angles to prevent rubbing and burnishing. Sometimes it is necessary to step up the revolutions of the cutter to obtain the necessary feet per minute after numerous grindings. Don't be satisfied if the job runs smoothly immediately. Experiment with feed and speed because depth of cut, number of teeth in cutter, width of cut and the general condition of the machine all enter into the picture. Perhaps conditions are such that you can gain higher production and longer tool life with a little experimentation.

Simple steps often can correct irregularities in drilling when accurate, straight holes are required.

When a drill jib suddenly starts to produce work not up to standard often the replacement of worn bushings will solve the difficulty. Bushings should be checked for concentricity as well as size before they are put in a jig.

Check Drill Size

Variations in standard drills can also cause trouble. If a tool setter selects drills which fit the drill bushing with the right amount of clearance much trouble can be avoided.

On the very ductile copper alloys chrome-plated drills often prevent galling. Sometimes fast spiral drills can be used but often the slow spiral type is more advantageous.

One cause of excessive drill wear can be overcome by not permitting the drill point to run in a bushing between operations. By completely removing the drill from the bushing not only is wear reduced but the drill is more rapidly cooled and chips washed away in the coolant.

When a bushing plate is used for drilling it is often necessary to have a split coolant flow—one hitting the top of the bushing and the other striking the work at the point of drill contact. This lower stream will also help to wash away chips during the operation and to clean the locating areas of the jig.

Hand sharpening of taps is quite common in the average shop, but where straight accurate holds are demanded it is advisable to use a drill sharpener.

Automatic drilling attachments for drill presses produce more consistently accurate parts than can be expected on a hand-fed job. This is especially noticeable on small drills where breakage is apt to be high on hand-fed operations.

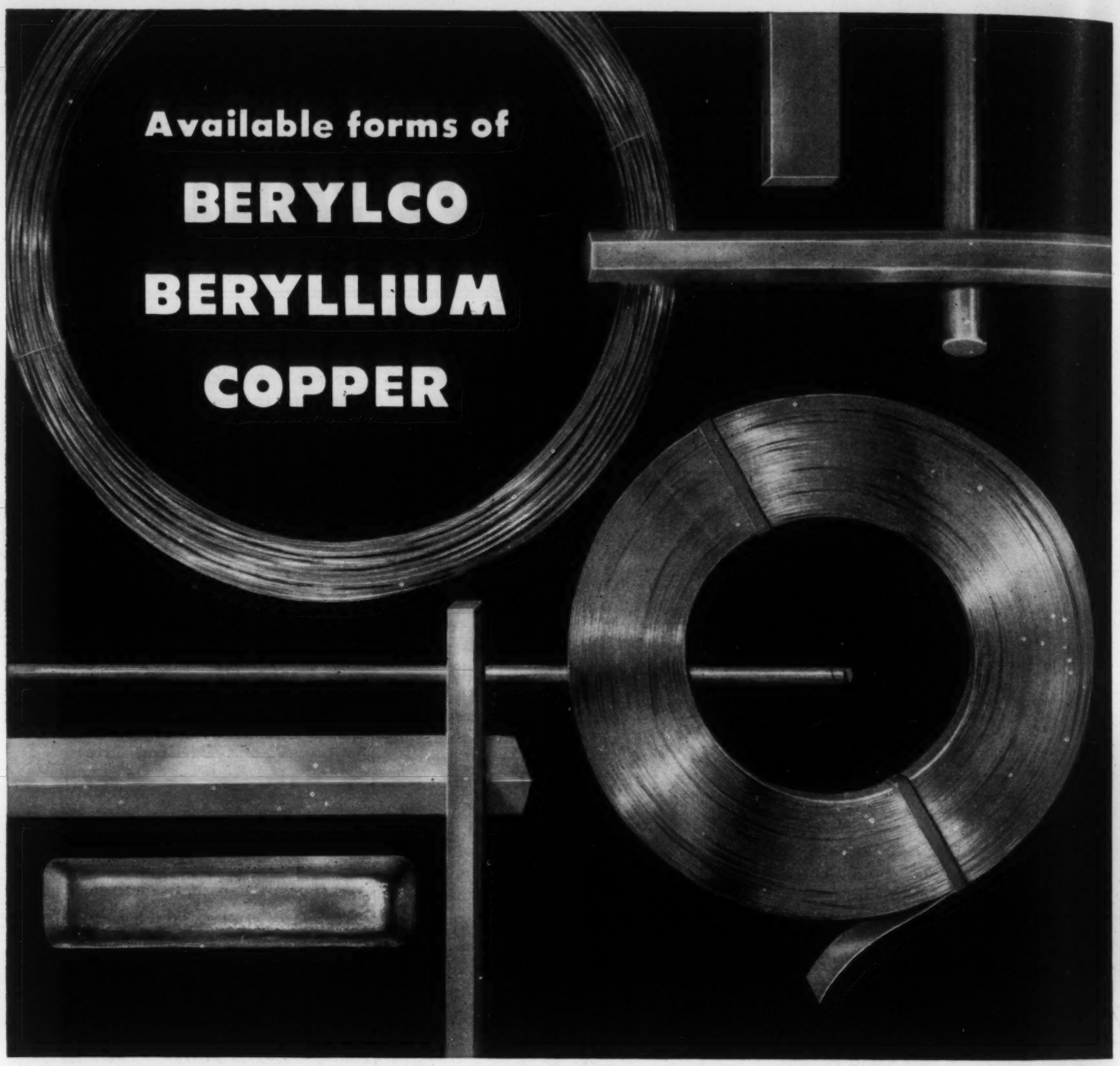
Check Drilling First

When holes fail to clean up during a reaming operation, check the drilling first. A reamer will only follow the drilled hole, it will not straighten it. Although leaving too much stock for a reamer to cut is a common error, most of the trouble comes from too little stock. The reamer then burnishes rather than cuts and undersize holes usually result.

Tapping of leaded copper-base alloys rarely proves a difficult job. However, in the non-leaded alloys and copper, polished flute taps which have been chrome-plated usually give satisfactory results. The plate both reduces wear and galling.

On through holes the chip driver, or gun tap, usually does an excellent job. With blind holes a standard tap is advisable unless there is plenty of chip clearance below the tapped area.

In drilling, reaming, tapping and milling it is generally desired to have well-directed, good flow. Just as in screw machine work, the choice of cutting compound depends on the alloy being machined. As the ductility of the alloy increases so should the viscosity of the coolant. Perhaps the main variation from this rule is in tapping where the speeds are normally such that little heat is generated and a heavy cutting compound is advisable to give the greatest amount of lubrication possible. (6635)



You can buy Berylco in casting ingots. You can buy it as rod and bar, in rounds, rectangles, hexagons or squares. You can buy it as heat-treatable and pre-tempered wire . . . or as cold-rolled, slit-edge strip.

However you buy it, Berylco will give you a unique combination of properties not otherwise obtainable. To find out what Berylco can do for you, take advantage of the technical knowledge of the world's largest producer of beryllium copper. Blueprint your problem—or send for sample material.

The Beryllium Copper Technical Bulletins, issued monthly, are full of helpful information about end uses. To receive your copy regularly, write on your business letterhead.

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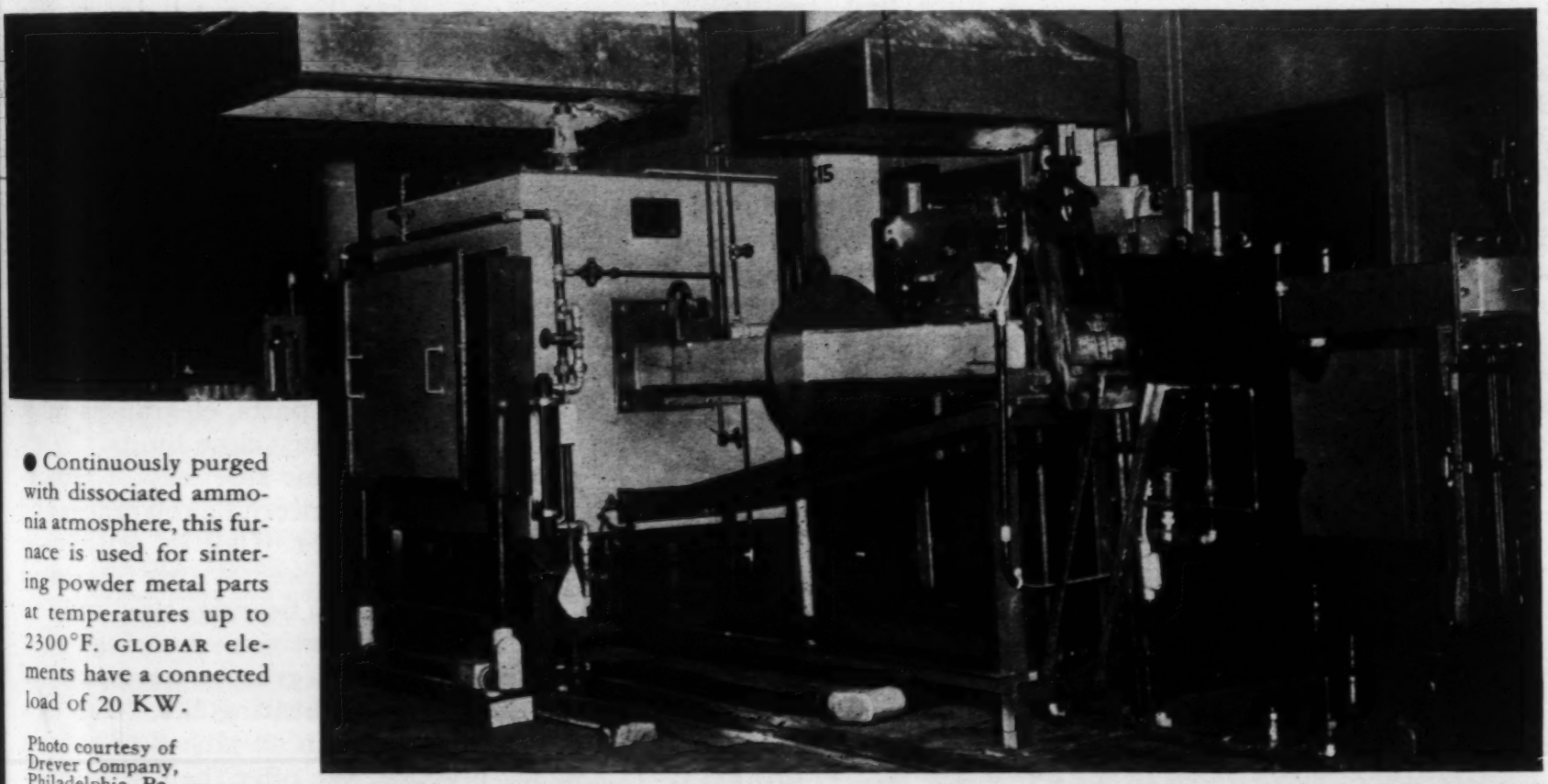
GLOBAR Heating Elements

for Controlled Atmosphere Sintering Furnace

Many operating advantages are realized through use of GLOBAR silicon carbide heating elements in heavy duty heat treating furnaces. They provide a wide temperature range... uniform work chamber temperatures... fast heating and accurate temperature control for production work. Special atmospheres may be used. Dependable operation for extended service periods is assured.

The rod-type construction of GLOBAR heating elements permits more efficient furnace designs. Installation of elements is simple and convenient. Work chamber capacity is increased. GLOBAR non-metallic heating elements are being used in an increasing number of high temperature heat treating furnace applications. Obtain detailed information on their installation and operation by writing Department W-61, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.



● Continuously purged with dissociated ammonia atmosphere, this furnace is used for sintering powder metal parts at temperatures up to 2300°F. GLOBAR elements have a connected load of 20 KW.

Photo courtesy of Drever Company, Philadelphia, Pa.

GLOBAR Heating Elements
BY CARBORUNDUM
TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

87-67

JOHNSON

SLEEVE BEARING DATA

Bearing DESIGN

BRONZE

SLEEVE BEARING DATA

Clearances

OIL CLEARANCE in sleeve-type bearings is that difference in size between the diameter of the shaft and the inside diameter of the bearing. This space accommodates the lubricant, permits the formation of a protective oil film preventing metal-to-metal contact when in operation and allows for expansion due to heat. Bearing performance, bearing life and machine operation are all greatly affected by oil clearances determined through correct dimensions of shaft and bearing.

It is quite impossible to set hard and fast rules for all applications. So many factors go into the successful operation of bearings that each should be given individual study and clearance data decided from the findings. However, certain general standards can be used as a guide towards correct oil clearances.

The above chart lists the average oil clearances most widely used for internal combustion engine applications. This applies to units in which a force feed, pressure lubrication system is used. The vertical clearance is generally maintained to low limits whereas higher clearance is maintained at split line, accomplished by eccentric bore or reliefs at parting line. For splash lubricated bearings, where the engine speed is less than 2000 R. P. M., the minimum oil clearance will be somewhat larger, varying from .0002 to .0006 per inch of shaft diameter.

INTERNAL COMBUSTION ENGINE BEARINGS

Dia. of Crankshaft Journal or Crankpin	*Oil Clearance between shaft and bearing on diameter*	*Crankshaft End Clearance*
2" to 2¾"	.0015 ± .001	.004 to .006
2 13/16" to 3½"	.0025	.006 to .008
3 9/16" to 3¾"	.003	.008 to .010
3⅞"	.0035	.008 to .010
4"	.004	.008 to .010

*This data computed on the use of white or babbitt metals.

BEARING CLEARANCES IN INDUSTRIAL APPLICATIONS

CLASS OF BEARING	*Running Clearance, Thousandths of an inch, for shaft dia. under*				
	½"	1"	2"	3½"	5½"
Precision Spindle Practice—Hardened & ground spindle lapped into the bronze bushing. Below 500 ft./Min. & 500#/Sq. In.	.00025 to .0075	.00075 to 0015.	.0015 to .0025	.0025 to .0035	.0035 to .005
Precision spindle practice—Hardened & Ground spindle lapped into bronze bushing. Above 500 ft./Min. & 500#/Sq. in.	.0005 to .001	.001 to .002	.002 to .003	.003 to .0045	.0045 to .0065
Electric Motor & Generator Practice—Ground Journal in broached or reamed bronze bushing or reamed Babbitt bushing	.0005 to .0015	.001 to .002	.0015 to .0035	.002 to .004	.003 to .006
General Machine Practice (Continuous rotating motion)—Turned steel or cold rolled steel Journals in bored & reamed bronze or poured & reamed babbitt bushings	.002 to .004	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
General Machine Practice (Oscillating Motion)—Journal & Bearing material as above	.0025 to .0045	.0025 to .0045	.003 to .005	.004 to .007	.005 to .008
Rough Machine Practice—Turned steel or cold-rolled steel Journals in Poured babbitt bearings	.003 to .006	.005 to .009	.008 to .012	.011 to .016	.014 to .020

Ordinary industrial applications can be governed by general clearance practice—as listed below. We have found, through more than 40 years exclusive bearing manufacturing experience, that the majority of applications can be so classified. The tolerance range, as shown by the chart, provides ample room for the formation of a protective lubricating film. In certain specific applications, such as some types of machine tools engaged in producing very precise parts, clearances must be held to very close limits.

There is one sure way of removing doubt concerning tolerances and oil clearances. Call in a Johnson Bronze Engineer. We are interested in giving you bearings that will suit your applications—bearings that will deliver greater performance and longer bearing life. Our men are trained in all phases of bearing practice. We offer their services to bearing users without obligation of any kind.

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
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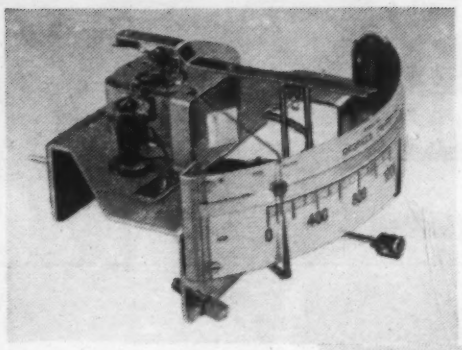
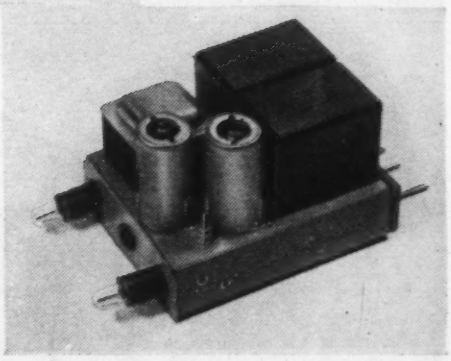
BROWN INSTRUMENTATION IS THE *Plus-Factor*

Now available

THE PYR-O-VANE WITH 3-POSITION CONTROL



Plug-in galvanometer measuring unit.



Plug-in electronic control unit.

Check These Outstanding Features:

- √ **COMPACT DESIGN**—*Requires only one amplifier and one set of vane coils. 9" wide x 10" high case, interchangeable for flush or surface mounting.*
- √ **INSTANTANEOUS CORRECTIVE ACTION**—*New high-resistance galvanometer and unique vane-type electronic control assure highest sensitivity with knife-edge control.*
- √ **PROTECTED GALVANOMETER & CONTROL UNITS** — *Separately enclosed. Practically immune to ambient temperature and humidity changes . . . less susceptible to vibration . . . withstands severe operating conditions.*
- √ **ADJUSTABLE NEUTRAL ZONE**—*Width of neutral zone adjustable from 1 to 5% of full scale. Set point index can be set at either end of neutral zone or anywhere within it.*
- √ **STANDARD TUBE**—*Uses standard 12AU7 tube. Can be purchased in any electronics store.*
- √ **SAFETY CHARACTERISTICS**—*"Fail-safe" design and thermocouple burnout feature protect work load.*

THE Pyr-O-Vane electronic millivoltmeter pyrometer has been acclaimed by industry in thousands of installations for its continuous, accurate control. Now, to further broaden its use, it has been made available with three-position control.

The three-position Pyr-O-Vane has the same advanced design features, and uses the same case as the popular two-position instrument. And it requires *only one amplifier assembly and one set of vane coils!* This means not only a more compact three-position controller, but a more economical one.

The instrument is ideal for control of certain electric or fuel-fired furnaces and ovens . . . for heating/cooling control . . . for delta-wye (Δ-Y) switch-over control . . . and for two-position control where a high limit control or alarm is desired. For further details write for Specification Sheet No. 114.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4517 Wayne Ave., Philadelphia 44, Pa.

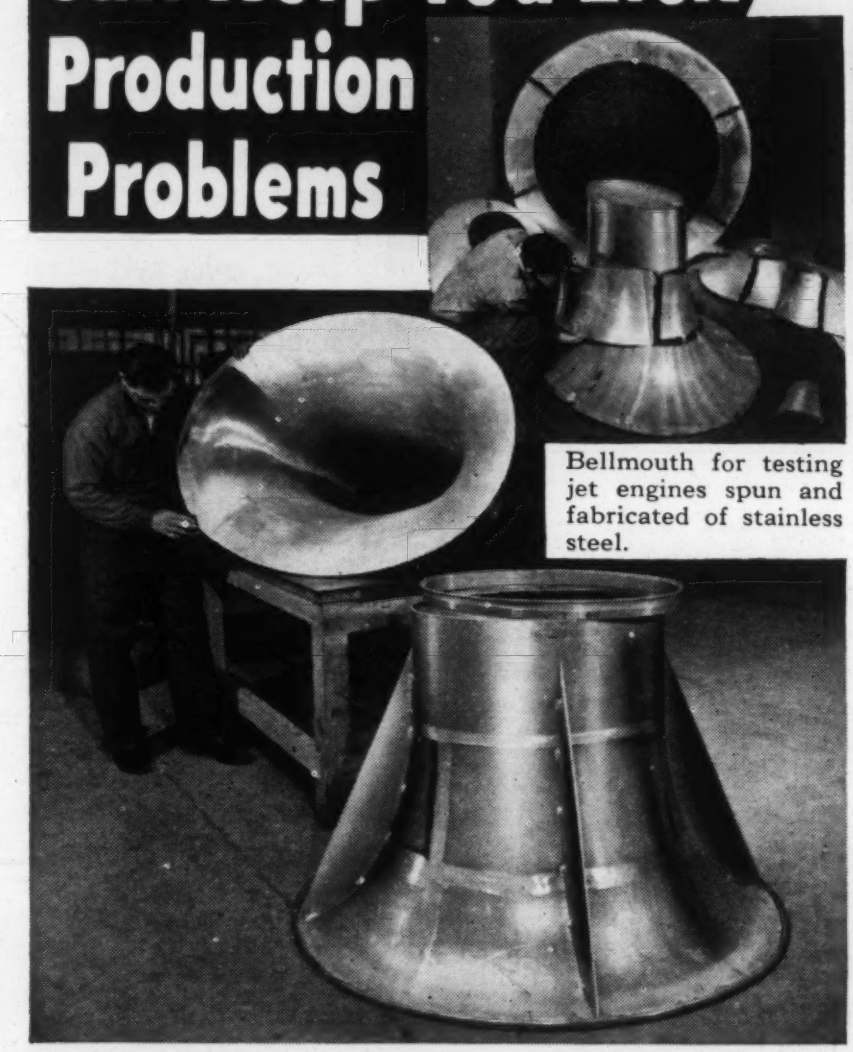
MINNEAPOLIS **Honeywell**

Brown Instruments

Cut the cost of dies
Gain weeks of time

Spincraft
SKILL WILL DO IT

spinning and fabricating can Help You Lick Production Problems



Bellmouth for testing jet engines spun and fabricated of stainless steel.

HIGH tooling costs — months of waiting time — the urgency of the hour — these very real conditions need not bring despair to able designers and alert production executives. Spincraft engineering may well provide you with a welcome solution at a small fraction of conventional fabricating costs and in far less time.

The parts or products you see here reflect what can be done by spinning and fabricating in combination. This resourceful approach provides a wide range of opportunities in many metals that you are invited to discuss with Spincraft engineers. The answer you want cannot be guaranteed, but others have been helped so often and so well that Spincraft has become the world's largest metal spinning and fabricating plant. Call or write

Send for the Spincraft Data Book—40 pages of engineering information that will be helpful to you.

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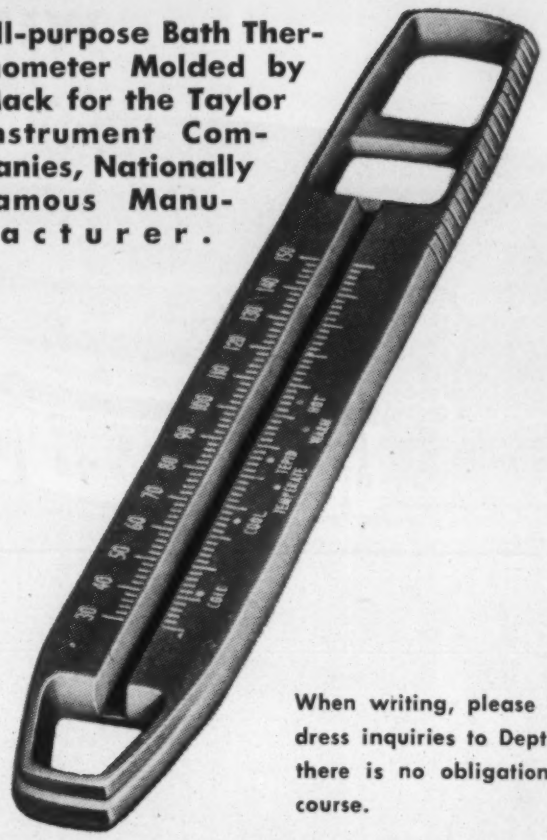
LET Mack FIGURE IT IN PLASTICS—

All-purpose Bath Thermometer Molded by Mack for the Taylor Instrument Companies, Nationally Famous Manufacturer.



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Figured any way you look at it, letting MACK figure on your plastic molding jobs makes good sense. In the business since the early days of the industry, MACK has the experience and the facilities to do the job right. Choice of materials, design and mold making, finishing and delivery are *all* carefully followed through to insure the *best* results for you. That's why many MACK customers have been with us for a quarter of a century. Inquiries are invited — address Mack Molding Co., Inc., Main Street, Wayne, N. J.

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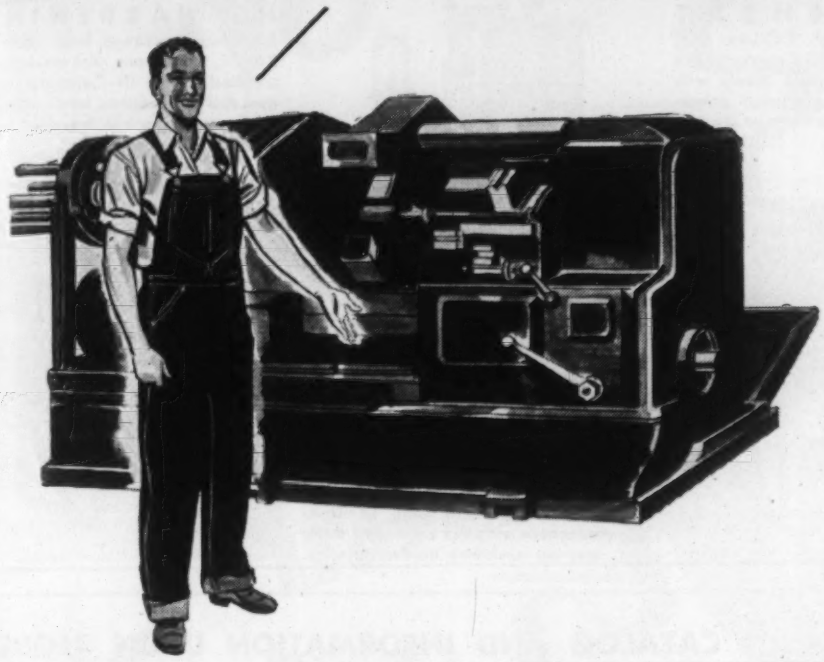
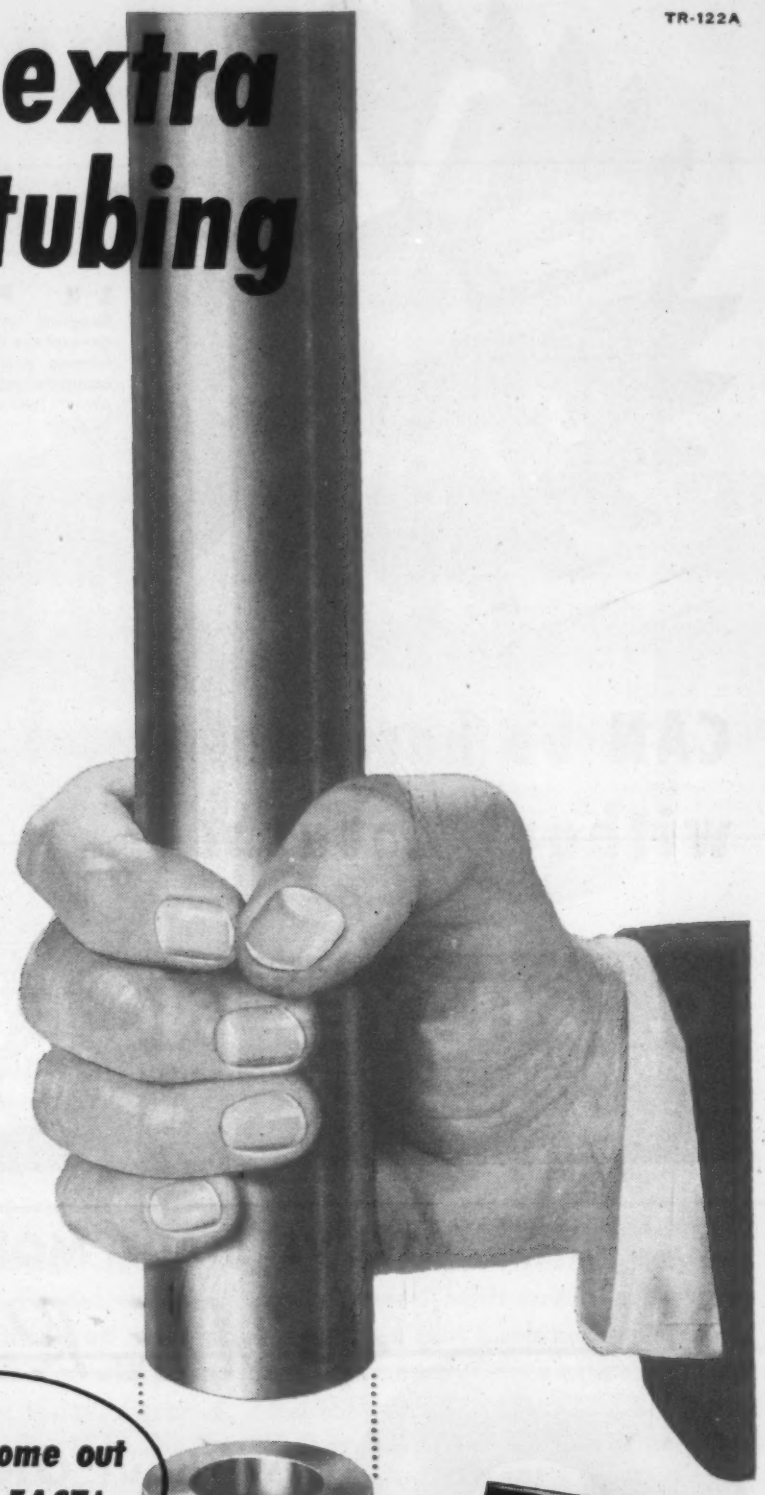
Mack MOLDED EXCELLENCE

TR-122A

It's like getting an extra machine with this tubing

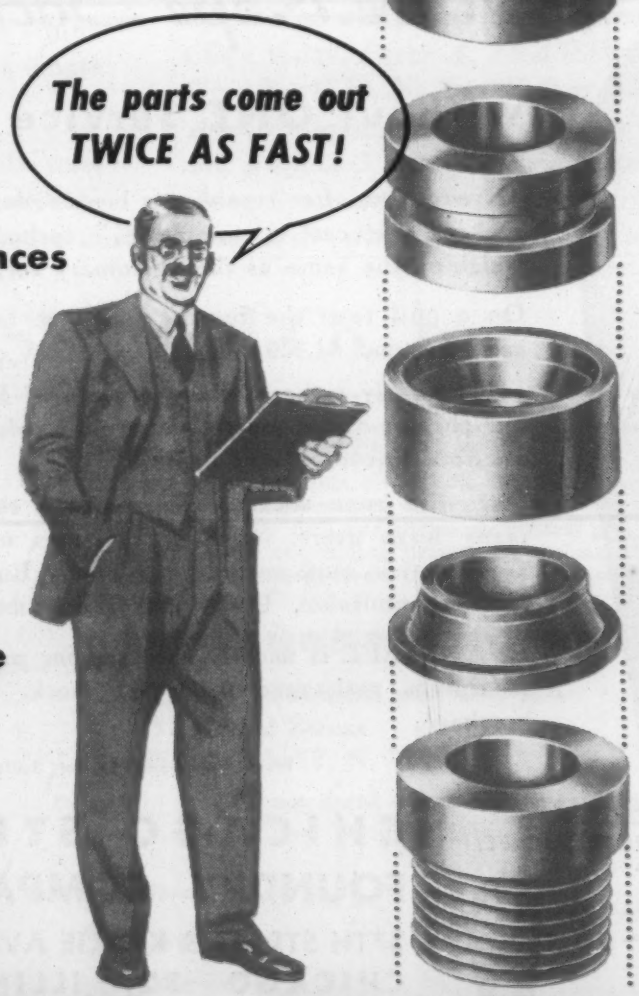


The output of ring-shaped and cylindrical parts can be stepped up as much as 100% by machining them from Rockrite Tubing. This means one automatic screw machine has the production of two. It's just as though an extra machine was added for each one on the line. **Naturally, machining costs are cut as much as 50%.** The reason? Rockrite Tubing is *compression-sized* to much closer tolerances than standard mechanical tubing. There's less metal to cut away, less finishing — perhaps none on outside or inside.



ROCKRITE SAVES MORE THAN ANY OTHER TUBING

- Higher cutting speeds
- Tools last longer between grinds
- Work-surface finishes are better
- Machined parts have closer tolerances
- Stations on automatics are often released for additional operations
- Extra-long pieces available — less down-time for magazine stocking and fewer scrap ends
- Closer tolerances often eliminate necessity for machining on outside or inside



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16-PAGE BULLETIN

tells how the unique Rockrite process provides greater tube accuracy which *multiplies* production of machined parts and *subtracts* costs. Write for your copy today.

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MOLY STEELS

CAN be hardened without decarb!

This equipment GUARANTEES IT

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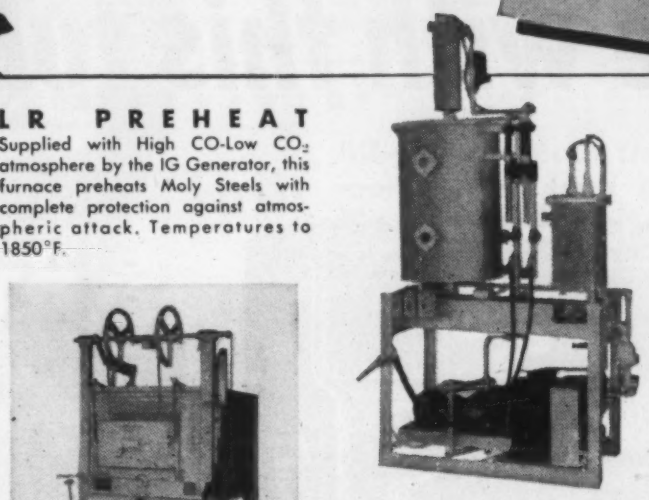
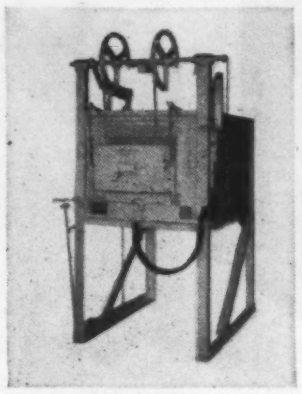
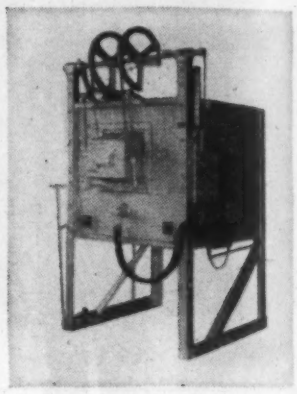
Supplied with High CO-Low CO_2 atmosphere by the IG Generator, this furnace preheats Moly Steels with complete protection against atmospheric attack. Temperatures to 1850°F.





IG GENERATOR
Developed to supplement and extend the "Certain Curtain" controlled atmosphere system originated by C. I. Hayes, Inc., this Generator produces High CO-Low CO_2 atmosphere with low controlled dew point, assuring scalefree hardening with NO decarburization.

HG HARDENING
Spanning the range from 1800 to 2400°F, this furnace, with atmosphere supplied by the IG Generator, hardens Moly High Speed Steels with fine finish and complete freedom from decarburization.



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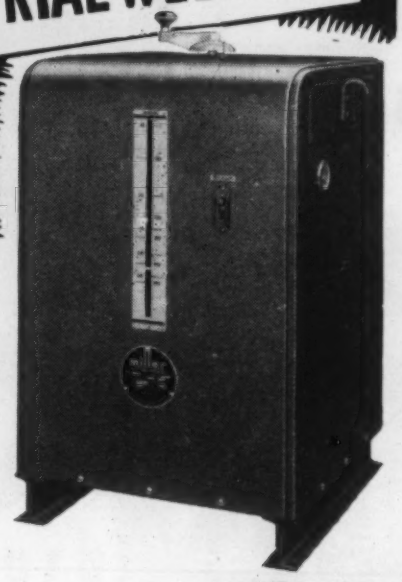

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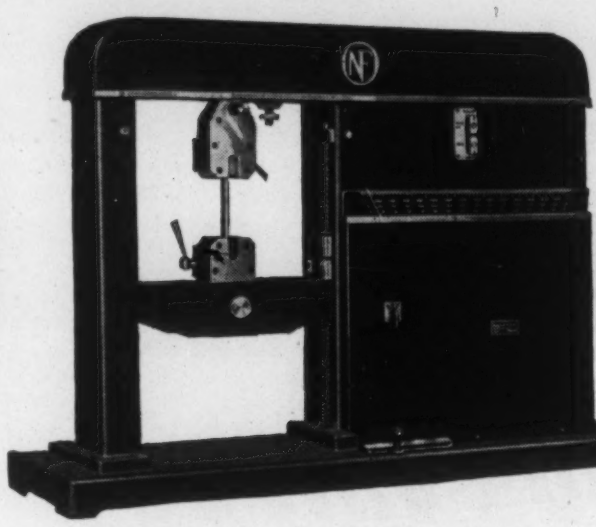

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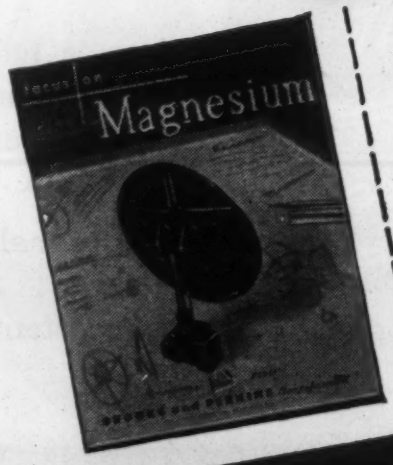

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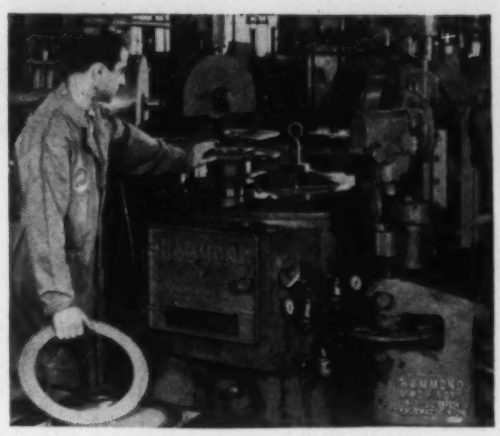
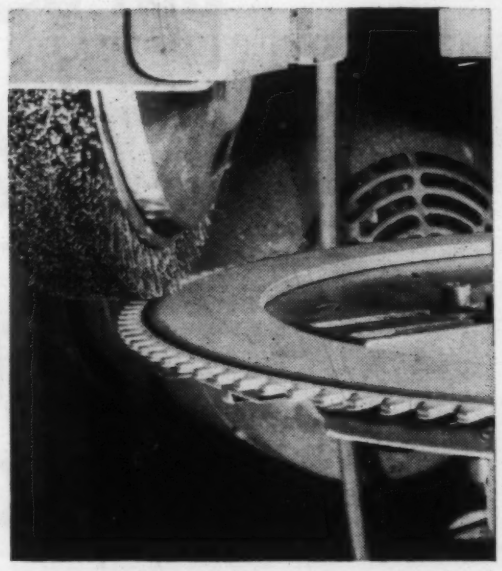
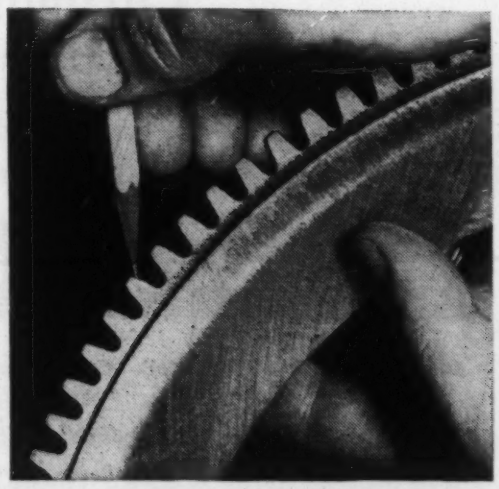


THE MACHINE . . . *a 5-head rotary automatic is used by this manufacturer to mechanize the brushing of clutch disc teeth. Each brush is powered by a 5 h.p. motor and rotates at 1750 r.p.m.*



THE OPERATION. *Four of the stations brush across the teeth like the one shown above. Fifth station brushes* into *the teeth.*



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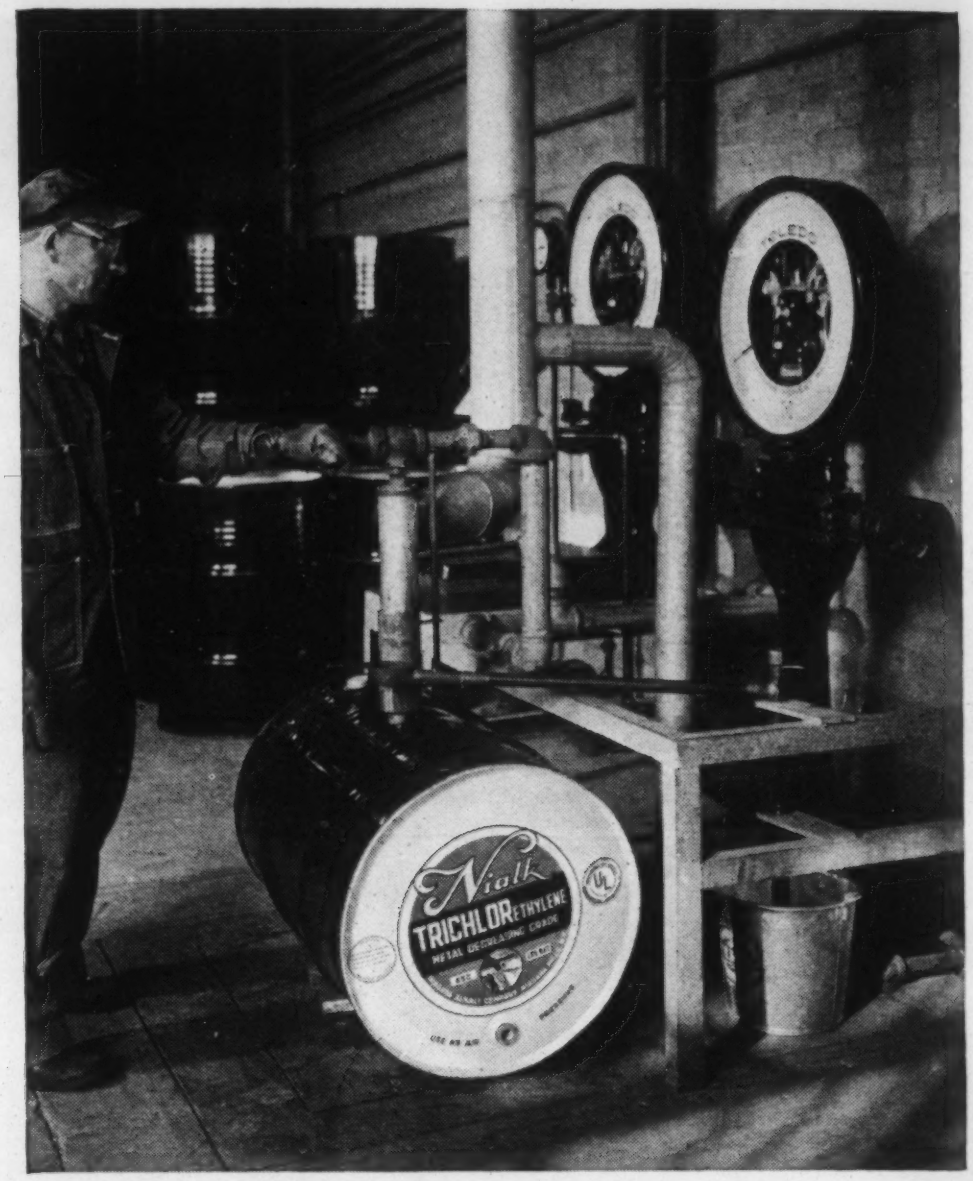

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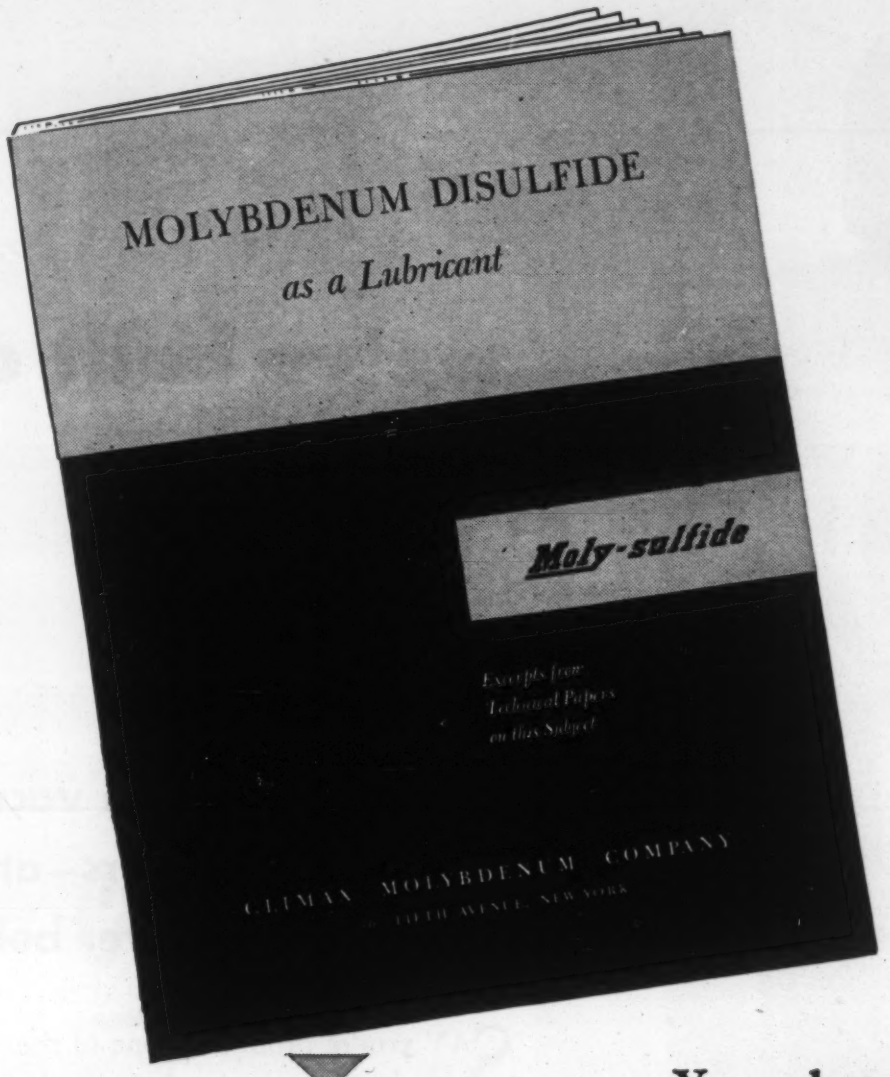

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